Applied Mechanics Reviews

A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

REVS. 1440-1849 VOL. 11, NO. 5 MAY 1958

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Published Monthly by THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS at Easton, Pa., and edited by Southwest Research Institute with the co-operation of Linda Hall Library.

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Subscription and Production Office: **The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., U. S. A.**

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APPLIED MECHANICS REVIEWS, May 1958, Vol. 11, No. 5 Published Monthly by the American Society of Mechanical Engineers at 20th and Northampton Streets Easton, Pa., U. S. A. The editorial office is located at the Southwest Research Institute, San Antonio 6, Texas, U. S. A. Headquarters of ASME, 29 West 39th St., New York 18, N. Y., U. S. A. Price $2.50 per copy, $25.00 a year. Changes of address must be received at Society headquarters seven weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Laws: The Society shall not be responsible for statements or opinions advanced in papers or printed in its publications (B13, Par. 4) . . . . Entered as second-class matter, January 11, 1948, at the Post Office at Easton, Pa., under the Act of March 3, 1897. ©Copyrighted, 1958, by The American Society of Mechanical Engineers.

APPLIED MECHANICS REVIEWS

VOL. 11, NO. 5 MARTIN GOLAND *Editor* MAY 1958

ELECTROANALOGIC METHODS

VI. Multiplication of grid-network efficacy by use of "tearing"

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PARTS I, II and III of this article [see AMR, January and February, 1956; February, 1957] respectively comprise an account of electroanalogic solution by continuous-type conductive (tank, plate, sheet or liquid surface) procedures of problems of electric and magnetic nature [1–111][1], of continuum mechanics (elastic, thermic, hydrodynamic, and aerodynamic) nature [112–314], and of the solution of like and other (electric, water, gas and steam distribution, electron-optics systems, and nuclear reactor design) problems [315–480] by the discrete-type conductive procedures afforded by d-c resistance networks. Part IV (see AMR, August, 1957) encompasses account of the basic theory of a most useful auxiliary with, and powerful supplement to, these conductive procedures: namely, the method of dimensional analysis [481–712]; and Part V (see AMR, October, 1957) enfolds accounts of this method in various branches of applied mechanics and, more generally, in numerous other domains of engineering science [713–976]. This Part VI entails account of the theory and application of "tearing"—a complementary procedure which greatly enhances the efficacy and values of grid-network electroanalogic procedures.

50. BASIC CONCEPTS

The genesis, development, and application to date of the theory of tearing has been effected largely by Gabriel Kron, one of the most original-minded of modern electrical engineering theorists. In four books and several-score papers, encompassing content and results which recall the nature, power, breadth, and vitality of Oliver Heaviside's work, Kron has ranged the domains of: electric systems analysis (passive and active networks, rotating machines, transmission and distribution networks, and u-h-f components); various electromagnetic and atomic-physics problems; certain phases of mathematical analysis; problems in discrete and continuum mechanics (elastic and plastic structures; compressible and incompressible hydrodynamic and aerodynamic fluid flow, thermal flow, and nuclear-particle flow); and particularized aspects of generalized dynamics. The details of this body of work are well-epitomized in Stigant's summary of each of Kron's books and papers (977, 978).[2]

[1]Numbers in brackets [] indicate references at the ends of parts I–V inclusive.

[2]Numbers in parentheses () refer to bibliography at end of this paper.

The prime aim in this work is that of simplifying, generalizing and enhancing the solution of old and new problems in these domains through formulation and development of new and powerful techniques of solution, as afforded by use of matrix and tensor analysis. The essential concept underlying achievement of this aim is that of "tearing." Originally, this enfolded the organization and setting-up of the equations of performance in a piecewise manner. That is, the actual technical or physical system under consideration is considered as an interconnected system of prime components, these latter comprising one or more "primitive" systems. Intershifting of the rather easily written equations of performance of the one or more primitive systems (viewable *in one sense* as the torn pieces of the system under consideration, hence the idea of "tearing") through appropriate use of one or more interconnection matrices or tensors yields the desired more complicated equations of performance of the stated system. This mode of procedure is essentially that exemplified in Kron's work published before, roughly, 1952 or so. One who would master this body of work might best (and easiest, in the reviewer's opinion) start by study of Kron's great book (979) on the matrix and tensor analysis of networks and fields (the technical content is fairly easy, the thematic development has the fascination of a well-written novel); and thereafter take up those papers concerned with his particular domain of interest, as indicated in Stigant's summaries (977, 978).

Though such approach afforded a unified piecewise procedure for obtaining the equations of performance of a complicated system, the attendant numeric and analytic labor and difficulties of solving the so-obtained general equations for a parametrically specified system yet remained; and in certain problems of much current interest—say, in the analysis attending design of a complex continuum-mechanics system such as a nuclear reactor or large-scale elastic structure—the computation or calculation necessary to solution of a desired degree of accuracy stressed, or even exceeded, the capacities of the electroanalogical means, or digital computer devices, at hand.

This shortcoming was largely obviated by Kron's eventual discernment of the links between piecewise setting-up, and piecewise solution, of the equations of performance. In this latter context (advanced about 1952 or so), "tearing" implies the sectioning or tearing of the electric or electroanalogic graph (or topologic model) of the system in an arbitrary manner into isolated parts; clipping these simpler subsystems; solv-

ing each subsystem (and in so doing, the earlier-developed tensor theory may well be made use of); constructing the appropriate "intersection" network; and solving this intersection network—wherefrom the desired solution of the given system can be obtained by simple computation well within the computing capacities in hand. This method of solution, involving a conjunction of tearing, tensors, and topological models, Kron (980) terms "Diakoptics" (from the Greek "dia" meaning "through" and "kopto" meaning "to tear"; hence, to "tear through" or "tear apart").

51. DETAILED THEORY

A well-detailed general account of this new diakoptic procedure is illustrated by solution of the finite-difference approximation of a boundary-value problem (such as in steady-state heat flow) requiring determination of the solution $E(x,y)$ of Poisson's equation $\nabla^2 E(x,y) = I(x,y)$ over a rectangular area and subject to specified $I(x,y)$, involving tearing a 336-mesh network into 11 smaller portions (981). Solution of finite-difference approximations of two-dimensioned electromagnetic boundary-value problems such as occur in waveguide and cavity-resonator problems requires somewhat simpler interconnections, hence a more easily comprehended analysis, stemming from the simpler boundary conditions (982–985). The same is true of the analysis of nuclear particle diffusion problems in reactor design (986, 987), of elastic distributed-parimeter systems (988, 989), of elastic pin-jointed frame structures (990–992), and of nonlinear plastic-range structures (993). Contrariwise, in intraconnected transmission-systems studies, as in power-pool ultization, attendant use of the more subtle concepts of real power and loss-coefficients, rather than current and impedance as in the electroanalogic representations of the previously remarked problems, conjoined with the desire for extremum solutions both requires a more abstract analysis and markedly evidences the flexibility and power of the method of tearing (994, 995).

In essence, the essential result stemming from use of tearing is obviation of the need of inverting large matrices. Such suggests that tearing can be utilized for effectively inverting large-size matrices by use of electroanalogic methods or digital computers which can directly provide inversion of only much smaller matrices. Account of the results of an actual study, check of the accuracy of results, and description of certain labor-saving steps pertiment to inversion of 256×256 matrix, characterizing solution of the finite-difference approximations of the diffusion-type partial differential equations of a cylindrical-form nuclear-reactor design problem, well evidences the utility and time-saving advantages of tearing (996). Description of the numerical detail of solution (997), especially as shortened by use of improved techniques (998–1000) and auxiliary electroanalogic aids (1001), makes clear the actual course of procedure. However, a somewhat faster grasp of actual calculation may well be facilitated by close study of the detail exhibited in several especially-simple systems (1000, 1002–1005) and treatments (1006–1008).

52. INTEGRATED ACCOUNTS

Statement (1009–1011) of the fundamental nature, diverse uses, and especial values of tearing, thus of diakoptic methods in general, as emphasized by Kron in his recent European lecture tour, comprise an interestingly written preface to this current series of papers devoted to advance of a systematic account of the analysis and solution of large-scale programs. Some ten or so installments have appeared to date (1012–1019).

In the large, Kron utilizes electroanalogic discrete-network representation of the system or analytic procedure under discussion. In some measure this might hamper a would-be user who has little or no knowledge of electric network theory. In such thought, a recent tightly-integrated establishment of explicit relationship between the method of tearing and orthogonal network analysis, utilizing the results of an earlier systematic study of the theory of tearing (1020, 1021), makes available the use of tearing with a minimal need of knowledge of electric network theory; extends and generalizes various phases of the theory of tearing; and advances numerical examples which both illustrate the course of this generalized theory and exemplify application of it in practice (1022, 1023).

53. ALGEBRAIC-TOPOLOGIC CONSIDERATION

In an exposition of his electroanalogic approach to the solution of problems in various mathematical, physical and technological domains, Kron (1024) suggested that the essential concepts of his thus-evolved theory of tearing could be reformulated and rigorously justified as a phase of the theory of algebraic topology: thus paralleling, in a chronological sense, the way in which the essential concepts of Heaviside's operational analysis, evolved by Heaviside in much the same spirit as Kron accomplished his theory of tearing, has been reformulated and rigorously justified in the development of integral transform theory. In precisely such fashion, Roth has established the validity of Kron's procedures of tearing and interconnecting (1025–1027), and discussed explicit construction of solutions via tearing, and other apposite theory (1028–1030). A technical "perspective" of Roth's approach is encompassed in Kron's current serial on diakoptics (1012–1017).

Perhaps the easiest-graphed and best-detailed account of tearing, as couched in algebraic-topologic terms, is to be found in recent Japanese work. Takada's (1031) systematization of tearing in solution of electric networks exemplifies the possibilities of diakoptics. Fuller fructuation is enfolded in Onodera's work on dual diakoptics. Herein, use of algebraic topology affords both a refinement of Kron's diakoptic technique (the equivalent networks are entailed on a nodal basis) and a formulation of the dual (the equivalent networks are entailed on a mesh basis), termed codiakoptics (1032). Detailed account of procedure and numerical detail, providing insight as to preferred choice of mode of solution for a stated system, are illustrated by two completely effected illustrative examples in a recent paper by Onodera and Ishiyama (1033).

Onodera's work comprises a part of a large-scale government-sponsored research investigation of the unification afforded solution of problems, both linear and nonlinear, in all domains of the engineering sciences by means of "geometry;" that is, the systematic use of such conjoined phases of analysis as differential geometry, algebraic topology, and matrix and tensor analysis. The results of this work to date, as encompassed in the Research Notes of the Research Association of Applied Geometry and in numerous papers in various journals, are well-evidenced in a remarkably written, recently published volume of variously authored papers (1034), which merits a most careful study by all who have interest or occasion to pioneer or to solve new and/or difficult problems in a particular area of applied mechanics, or in engineering science in general. An excellent summary of essential content, which details the various domains of application, is afforded the possibly interested reader in a recent review (1035).

54. SOME OTHER APPLICATIONS

In addition to the afore-mentioned numerous and diverse applications of tearing, as a multiplicative complement of electroanalogic procedures, the following representative areas of application may be remarked—as suggested by cited papers encompassing use of matrix and/or tensor analysis in the solution of problems considered therein: structural analysis (1036), piping flexibility analysis (1037–1039), multiple input

automatic-control systems (1040), complex vacuum-tube and transistor circuits and assemblies, as in digital computers (1041), large-scale electromagnetic and electromechanical machine systems (1042, 1043), aircraft and missile dynamics (1044), nuclear, atomic and molecular eigenvalue problems (1045), and the complex mechanics of fluid and gaseous media (1046).

55. CONCLUSION

Part VII of this series advances account of associated analogic methods which comprise useful supplements and conjointures of electroanalogic methods. And, for inclusion in a subsequent addendum to the series, the author would appreciate receiving note of pertinent references not listed in the present six parts.

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Theoretical and Experimental Methods

(See also Revs. 1447, 1471, 1472, 1473, 1475, 1478, 1479, 1486, 1487, 1496, 1497, 1503, 1582, 1585, 1622, 1669, 1670, 1671, 1672, 1675, 1724, 1729, 1731, 1732, 1739, 1744, 1779)

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Tensors whose components in rectangular Cartesian coordinate systems are invariant under the orthogonal group are called isotropic. If they are invariant under a subgroup $[T]$ they are called anisotropic. For multilinear polynomials which are form-invariant under $[T]$, authors use a well-known representation by a polynomial basis. From this follows that any tensor which is invariant under $[T]$ may be expressed by a tensor basis. Examples of such a tensor basis are given for monoclinic-domatic and rhombic-pyramidal classes of crystal symmetry.

R. Albrecht, Germany

Book—1441. Zubov, V. I., The methods of A. M. Lyapunov and their application [Methody A. M. Lyapunova i ih primenenie] Moscow-Leningrad, Univ. Izdat, 1957, 241 pp. 12.35 rubles.

Book is one more of the long and superb series of recent Soviet books on differential equations. More than ever it emphasizes the supremacy of Soviet Science in this particular chapter of mathematics. The shadow of Lyapunov hovers over it all. The book is therefore appropriately dedicated to the centenary of the birth of Lyapunov and begins with a portrait of that outstanding savant.

Briefly speaking, this work deals with the stability of dynamical systems a la Lyapunov in the most general sense possible: stability of singular points of standard systems, of their invariant closed sets, of solutions of partial differential equations. The basic method is Lyapunov's second, whose converse (sufficiency) is constantly and profoundly dealt with in accordance with the latest results (notably of Krasovskii). In addition, the first method of Lyapunov is also studied at length and with notable extensions.

By way of comparison, this first-rate book is not a text but has rather the character of the general volumes of the Colloquium Series.

A detailed analysis follows.

Chapter I. Stability of invariant sets of dynamical systems in metric spaces. After preliminary general definitions, general dynamical systems in a metric space are defined following Niemitzki-Stepanov, as a field of operations of a one-parameter additive group. Stability, ordinary or asymptotic, uniform or otherwise, are all defined for closed invariant sets. Theorems stating necessary and sufficient conditions are given. For asymptotic stability they include Krasovskii's condition: nonexistence of any complete trajectory in some neighborhood of the set. They are also expressed in terms of a functional V which plays the role of the Lyapunov function in this very general context. Application is made to distance estimates of a motion from an invariant set.

For asymptotic stability, the maximal region for such stability is dealt with, and, in the Euclidean space case, conditions assuring that it be the whole space are also given.

Chapter II. Application to ordinary differential systems. Extensive application is made of the general theory to autonomous and nonautonomous systems (isolated singularity), and in particular to analytical and to homogeneous systems.

Chapter III. The first method of Lyapunov. This method, valid only for analytical systems, rests upon the explicit series expansions of the solutions near a singularity. It is extensively dealt with in the chapter.

Chapter IV. Stability of invariant sets of general systems. Take an n-vector system

$$\dot{x} = X(x;t),\ t \geq 0 \qquad [1]$$

in which $E_n x\ [t \geq 0]$ satisfies the condition for the existence of solutions, but not necessarily conditions for uniqueness. Given (x^0, t_0), let $F_{t_0}^{t}(x^0, t_0)$ denote the set of all points for $t \geq t_0$ on the solutions through (x^0, t_0) for $t \geq t_0$. The discourse applies to the collection $[F]$ (nonmetrized) called a general system, and the theory developed in chap. I is applied to them (the definitions are repeated for this case).

Chapter V. Application to partial differential equations. This is assuredly the most striking part of the book. Take a system of differential equations

$$u_t = f(u, u_x, x) \qquad [2]$$

(finite dimensional vectors throughout) and a vector $\phi(x)$ with Φ as its metrized space (dim ϕ = dim u). Suppose everything adequately continuous and that for every ϕ there is a solution $u(\phi,t)$ such that $u(\phi,0) = \phi$. Thus $u(\phi,t)$ is a dynamical system in Φ to which most of the results of chap. 1 are extended.

S. Lefschetz, USA

1442. Krutov, V. I., Analysis of the stability of high-order systems by means of the charts of Professor I. A. Vyshnegradsky (in Russian) Internal combustion engines, Moscow, Mashgiz, 1955, 207–214; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7192.

Putting $H(\lambda) = 0$ as the characteristic equation of a linear system, it follows from a preliminary proposition demonstrated by Gurwits that the condition of stability of the system depends on the interchangeability of the roots of the following equations

$$R_e H(i\omega) = 0,\ I_m H(i\omega) = 0 \qquad [1]$$

If the exponent of $H(\gamma)$ (an omission occurs in the original text) does not exceed 7, the exponents of $R_e H(i\omega)$ and $I_m H(i\omega)$ will not exceed 3. To calculate the roots of Eq. [1] for the case when they have a third power, it is suggested to use the well-known method of I. A. Vsyhnegradsky, developed by G. G. Kalisch and V. I. Krutov [*Tr. NAMI* no. 57, 1949], enabling the roots of a given equation of the third order to be determined.

M. A. Aizerman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1443. Karaseva, T. M., On a criterion for boundedness of solutions of Hill's differential equation (in Russian), *Prikl. Mat. Mekh.* **20,** 4, 549–551, July-Aug. 1956.

In the differential equation (*) $y'' + p(t)y = 0$, let $p(t) = p(t+T)$ and $\int_0^T p(t)dt = 0$. Author shows that if $T\int_0^T q^2(t)dt < \pi^2/4$, where $q'(t) = p(t)$, and $\int_0^T q(t)dt = 0$, then all solutions of (*) are bounded. This corrects an earlier conjecture of Krein [title source **19,** pp. 643, 668, 1955]. R. E. Gaskell, USA

1444. Razumikhin, B. S., On the stability of systems with retardation (in Russian), *Prikl. Mat. Mekh.* **20,** 4, 500–512, July-Aug. 1956.

N. N. Krasovsky [*Prikl. Mat. Mekh.* **20,** 314–327, 1956] generalized a method of Lyapunov, introducing a test functional [l.c., p. 317] to make it applicable to systems with retardation. Author extends this work to the system

$$dx_i/dt = X_i[t;\ x_j(t),\ x_{jk}(t-\tau)] \quad (i,j = 1, \ldots n;\ k = 1, \ldots m)$$

X_i being continuous and bounded in the region $t \geqq t_0,\ |x_j| < H$ (const). Results are neatly stated in eight theorems, each listing stability or asymptotic stability of the system as determined from Krasovsky's test functional. Several specific examples are included. R. E. Gaskell, USA

1445. Quade, W., Numerical integration of ordinary differential equations by Hermitean interpolation (in German), *ZAMM* **37,** 5/6, 161–169, May/June 1957.

Hermitean interpolation consists in replacing a function $g(x)$ by a polynomial which agrees, for some given abscissas, with both the ordinates and the first derivatives of $g(x)$. If $y = g(x)$ is the solution of a first-order differential equation $y' = f(x,y)$, Hermite interpolation polynomials lead to a family of formulas for numerical integration, just as ordinary (e.g., Lagranian) interpolation polynomials are used to derive some of the classical formulas for numerical integration, like those of Adams-Bashforth. For the simplest cases, using only two or three abscissas, the formulas obtained by Quade are identical with known ones; for the higher cases, Quade's formulas are new, and are generally more accurate than known formulas of the same order. Formulas of both closed-end and open-end type are derived. The latter furnish an explicit expression for a new ordinate, say y_n, (more precisely, for the increment $y_n - y_0$) as a linear combination of previously computed ordinates $(y_1, \ldots, y_{n-1})$ and derivatives $(g_1' = f(x_1, y_1), \ldots, g_{n-1}' = f(x_{n-1}, y_{n-1})$. The former include $g_n' = f(x_n, y_n)$ (and also g_0') in the expression for $y_n - y_0$, so that one has an equation which must first be solved for y_n. The corresponding classical formulas, by contrast, express $y_n - y_0$ in terms of $g_1' \ldots g_{n-1}'$ or $g_0' \ldots g_n'$ only, without using $y_1 \ldots y_{n-1}$ explicitly.

The paper lists a number of convenient formulas, and for each gives an approximation to the truncation error (simply the first neglected term in a Taylor series). Some of the formulas given pertain to equidistant arguments, others to the so-called Chebyshev arguments, which result in greater accuracy. Particularly interesting are some formulas in which irrational Chebyshev abscissas are approximated by integer multiples of a grid constant h, thus preserving all the advantages of equidistant abscissas and attaining almost the same accuracy as with Chebyshev abscissas. For instance, the five-point Chebyshev abscissas $0, \pm 1/\sqrt{2}, \pm 1$ are replaced by $0, \pm 2h, \pm 3h$ (by setting $1/\sqrt{2} \sim 2/3$ and referring the abscissas to an interval of length $6h$), thus in effect obtaining a seven-point formula in which two of the ordinates have weight zero. The resulting integration formula has an error term of order h^9. F. L. Alt, USA

1446. Salzer, H. E., and Roberson, Peggy T., Table of coefficients for obtaining the second derivative without differences, San Diego, Calif., Convair-Astronautics, 25 pp., 1957.

Report gives title coefficients based on the n-point Lagrangian, $n = 5(1)9$. Tables permit evaluation of second derivative at points intermediate to the base points. Y. L. Luke, USA

1447. Harmuth, H. F., On the solution of the Schroedinger and the Klein-Gordon equations by digital computers, *J. Math. Phys.* **36,** 3, 269–278, Oct. 1957.

Paper considers the stability of finite difference analogs to title equations. The stability criterion employed and analysis follows that originally devised by J. von Neumann.

Paper also illustrates this concept with the well-known heat-flow equation. A computing scheme for the Schroedinger equation is described. Y. L. Luke, USA

1448. Luke, Y. L., and Fettis, H. E., On the evaluation of the Schwarz function, *J. aero. Sci.* **23,** 10, 975–976 (Readers' Forum), Oct. 1956.

A complex integral arising in flutter theory is evaluated by replacing the Bessel function appearing by a finite sum of elementary functions. The sum is obtained by applying the trapezoidal rule to an integral definition of the Bessel function. Reviewer believes the method to have wide applicability.

C. Ablow, USA

Book—1449. Wallace, F., Appraising the economics of electronic computers, New York, N. Y., Controllership Foundation, Inc., 1956, 106 pp. $4.

Written from the viewpoint of management and with major emphasis on accounting applications, this book will be of little value to the average engineer. It does, however, outline a procedure for the economic justification of a digital computer that has been followed by a number of companies and as such should be of interest to one selected to serve as a technical representative on a management computer committee. Seventy pages are devoted to determining the necessity for a computer study, organizing the study, procedure analysis, cost analysis, and installing a computer system. A thirty-page appendix includes a computer primer, a payroll and labor distribution problem, a brief summary of available computers, and a superficial discussion of Operations Research.

G. C. Wallick, USA

1450. Palmer, P. J., and Redshaw, S. C., An electrical resistance analogue with a graded mesh, *J. sci. Instrum.* **34,** 10, 407–409, Oct. 1957.

Constructional details, supported by line drawings and illustrations of the completed networks, are given for an electrical re-

sistance analogue with a graded mesh, comprised of insulated resistance ribbon encapsulated in resin. Eight separate units, three of uniform mesh, three graded in only one direction, and two graded in both directions, comprise the whole assembly. Joining the individual boards so as to give a fine mesh along one side of the board over a limited region is appropriate to airfoil problems. A second jointure, giving a coarse grading over three sides of the board, is suited to study of viscous flow through porous media. Various other problems of elasticity, fluid mechanics, soil mechanics, and heat transfer are readily solved with excellent accuracy. T. J. Higgins, USA

1451. Schuster, D. H., Simulation of discontinuity nonlinearities, *Instrum. and Automat.* **30**, 4, 698–702, Apr. 1957.

1452. Simokawa, Y., and Morita, K., On the high precision concurrent charts, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 521–525.

An algebraic method for nomographization is shown for several examples, transforming the original equations into simple form expressed by straight line. Y. Takahashi, Japan

1453. Kahn, A. B., A generalization of average-correlation methods of spectrum analysis, *J. Meteor.* **14**, 1, 9–17, Feb. 1957.

Author develops the power spectrum of truncated variables as the transform of the correlation function of data smoothed by an arbitrary mean and as a function of both lag and averaging intervals. The method developed is quite elaborate for practical applications. It has, however, the merit of unifying the various approaches used in spectral analysis problems and, furthermore, it enables one to obtain the phase spectrum of the process, not otherwise possible to get by using the conventional correlation method. P. Nesbeda, USA

1454. Barrer, D. Y., Queuing with impatient customers and indifferent clerks, *Operat. Res.* **5**, 5, 644–649, Oct. 1957.

Author's summary states "A waiting-line problem in which the arrival and service rates are of Poisson type is considered subject to the additional conditions that (a) each customer is limited to a fixed time during which he is available for service and after which he automatically leaves the system, and (b) customers are selected at random from among those in the system rather than on a first-come first-served basis. The equilibrium distribution of the length of the queue and the expected rate at which customers escape service are obtained. The expected escape rate is plotted as a function of the limited time of customer availability for selected arrival, and service rates are compared with the result of Monte Carlo trials of the model."

Reviewer comments that the problem can be considered as a stochastic interpretation of military situations, e.g., attacking planes are engaged by anti-aircraft fire (or, in these enlightened times, guided missiles) only when within range. The queue approach allows an evaluation of the probabilities of survival. The expected survival rate is

$$C = \lambda - \mu(1 - P_0) = \lambda [1 = \rho (1 - P_0)]$$

where λ is mean arrival rate (Poisson), μ is mean service rate (exponential) and P_0 is the probability that the system is empty. As utilization increases, the survival rate increases. The close agreement between Monte Carlo trials and the computed results indicate that equilibrium state is approached rapidly.

E. Koenigsberg, USA

1455. Barrer, D. Y., Queuing with impatient customers and ordered service, *Operat. Res.* **5**, 5, 650–656, Oct. 1957.

Impatient customers are defined as whose who will wait, at most, a fixed time r_0 after which they become lost customers. The approach here is related to a previous paper (see preceding review) by the same author. The change-of-state equations are set up for two models; (a) only customers who wait a time r_0 before being acquired for service are lost and (b) if total waiting time is r_0, customer is "lost" even if he has already entered the service unit. The principle interest is in determination of the fraction of customers "lost".

The second model differs from paper cited only in method of selection of customers for service, i. e., a first-come first-served basis rather than in a random order. In terms of customer service the first-come first-served doctrine is preferred. Comparative lost customer ratios are plotted. The first-come first-served doctrine reduces the lost customer ratio only slightly. Paper is well-organized and clear; the approach may be suitable for other related queue problems. E. Koenigsberg, USA

Book—1456. Taton, R., Reason and chance in scientific discovery, New York, Philosophical Library, Inc., 1957, 171 pp. $10.00.

This book is translated from the French by A. J. Pomerans. Its author's purpose is to discuss, by means of historical examples, the factors influencing achievement of scientific breakthroughs. He begins with the psychology of the investigator, considering first mathematics and then the theoretical and experimental sciences. The other sciences differ from mathematics in the provisional character of their theory and in the necessity for confirmation of theory by experiment. [The differences between mathematics and the other sciences are so profound that Morris Kline, in "Mathematics in western culture", (New York, Oxford University Press, 1953), has asserted that mathematics is not a science at all.] In all, however, flashes of revelation during periods of relaxation after—and only after—long study of a problem have, in numerous instances, shown the solution. The reasons for this are discussed, as is the necessity of systematic doubt of generally held theories. But, "An experiment without any *a priori* assumptions whatever runs the grave risk of being sterile."

Where a precise problem is not presented, certain guiding thoughts are often fruitful in research: the ideas of analogy and of invariance; the wish to generalize; the urge to explain experimental facts; the idea of verifying hypotheses.

In discussing the role of chance, Taton points out that only prepared minds benefit from purely fortuitous observations. Error, too, although ordinarily harmful, sometimes plays an essential role in scientific discovery. Taton distinguishes among simplifying errors, which aid the establishment of theories which are really first approximations; false hypotheses; and false problems.

Scientists may miss discoveries or inventions because of: (1) too rigid an approach; (2) insufficient theoretical background; (3) inadequate financial resources; (4) insufficient attention to practical applications. When discovered, new ideas must often overcome theological and/or political resistance to survive, or, what is worse, hostility from other scientists.

In conclusion, Taton warns that, while organized collective research has made possible systematic exploitation of some results and improvement of some techniques, it may well lead to "a decrease of purely disinterested research work, in favor of an immediately profitable approach," and to a reduction of that individual initiative which is most essential to scientific discovery.

The historical examples with which the author illustrates his points are drawn from a wide variety of sciences. Many may be unfamiliar to English readers. For instance, in discussing the historians' problem of differentiating between precursors and true innovators, Taton quotes a letter written in 1783 by Volta in which Volta, speaking of the balloons of Charles and the Montgolfiers, tells of having experimented with hydrogen-filled soap bubbles and even bladders (too heavy to fly, however), and of having shown these experiments to Charles. Reviewer has examined some eight or ten English and American histories of flight without finding any mention of Volta, even though the similar experiments of Cavallo in London may be discussed at some length.

The book is illustrated with line drawings and 32 unusual plates. It will be of interest to all who are interested in either the psychology or the history of scientific research.

A. D. Topping, USA

Book—1457. Condoyannis, G. E., Scientific German; a concise description of the structural elements of scientific and technical German, New York, John Wiley & Son, 1957, x + 164 pp.

Book—1458. Locke, W. N., Scientific French; a concise description of the elements of scientific and technical French, New York, John Wiley & Sons, 1957, vii + 112 pp.

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 1495, 1511, 1645, 1760)

Book—1459. Hinkle, R. T., Design of machines, New York, N. Y., Prentice Hall, Inc., 1957, xi + 188 pp., $4.

This text is primarily a problem book, containing twenty "short problems" and seven "long problems." Included also are three chapters (64 pages) containing review and transition material. Each long-problem chapter contains a descriptive discussion of the machine or machine element involved. The author states in the preface that "this book is primarily for use in a second course in machine design" and that "the student should keep his first course book to use with this one."

In chapters 1 through 3, author presents some "basic concepts" of strength of materials along with several design techniques intended to illustrate the required practice of compromise. This he has titled optimum design and defined as that which must usually be done to "make the greatest profit for the company."

Chapters 5 to 11 contain a long problem each—centrifugal coupling, oscillating conveyor, thrustor brake, gear reducer, yoke riveter, nonuniform beam and manual lift truck. Each chapter also contains an illustrated discussion of the device in question, as well as some design considerations. The statement of the exact problem is left to the instructor in the case of the gear reducer and manual lift truck.

The appendix at the end of this 188-page book contains design data such as material properties, stress-concentration factors, beam formulas, wire sizes, thread data and elements of sections.

It might be pointed out, in conclusion, that the author has attempted a deviation from the unfortunate but too-often-used academic type of single-answer problem. However, it is the reviewer's opinion that he be encouraged to carry this farther, thus making the problems real exercises in creative design.

J. P. Vidosic, USA

Book—1460. Bainer, R., Kepner, R. A., and Barger, E. L., Principles of farm machinery, New York, N. Y., John Wiley & Sons, Inc., 1955, xi + 571 pp. $8.75.

A general course in farm machinery, intended for all agricultural engineering students and for others posesssing a certain technical background. The first chapters deal with progress achieved in mechanization, field performance, and cost analysis. Further, the materials of construction for farm implements and the calculation of various machine parts are presented. Emphasis is placed upon hydraulic controls and power-take-off drives, which are treated in a separate chapter. Tillage force analysis is clearly indicated in details. Then, moldboard-type tools, disk tools, various tillage and earth moving equipment are described. Crop-planting methods and their technical requirements, application of fertilizers, and forage chopping and handling are indicated. Special chapters are devoted to harvesting of grain, cotton, and root crops. The last two chapters discuss control of agricultural pests and farm transport.

Authors succeed in presenting a useful work which covers many important problems in the farm machinery field. It is worth mentioning that each chapter contains a number of problems and a large reference list.

C. Pelecudi, C. Florescu, N. Zelingher, Roumania

1461. Roberson, R. E., Torques on a satellite vehicle from internal moving parts, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-39, 5 pp.

Perturbations in the attitude motion of a satellite vehicle may have a cause in the motion of parts of the vehicle. Article deals with perturbations in the rotation of the whole satellite about some axis caused by motions—that are prescribed time functions—of its parts. The basic equations and results of this theoretical approach are written in a compact form by using vector notations. The developed theory is applied to three simple examples at the end of article. Article gives some insight on how to counteract undesirable perturbations and how to get the desired attitude motion of a satellite vehicle.

J. H. Van de Stadt, Holland

1462. Mewes, E., Unbalanced inertia forces in slider-crank mechanisms of large eccentricity, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-41, 8 pp.

A harmonic analysis is presented of the inertia forces in an offset slider crank whose connecting-rod's center of gravity does not coincide with the bearing centers. The formulas are expressed in terms of the ratios of offset distance and crank length to the connecting rod length. Accuracy of the numerical results and the effect of offset on the coefficients are discussed. In addition, rules are given for the full or partial balance of harmonic components of a specified order.

B. W. Shaffer, USA

1463. Popov, V. L., The influence of the centrifugal forces of inertia on the tension of the links in a working chain transmission (in Russian), O. Tsepnykh peridachakh., Moscow, Mashgiz, 1955, 64-76; *Ref. Zh. Mekh.* 1956, Rev. 5771.

Formulas are evolved to show the tension on the chain due to centrifugal forces in the case of even distribution of the mass over the length of the chain and uninterrupted engagement of the chain with the sprocket (flexible belt) and in the case of the spacing of the chain on the sprocket in view of the presence of a rectilinear polygon and the necessity for the periodical engagement of its links with the sprocket. In the second case the mass of the chain is presumed to be distributed over its links.

The relative difference is shown in the magnitude of the tension obtained in these two cases, and if the angular pitch is less than 20° then the relative difference is less than 1.5%.

It is shown that the magnitudes of the centrifugal tension in the links of the chain do not depend on the transmissonal relationship of the transmission, but that centrifugal tensions, originating from sagging of the chain, are evaluated in the same way as in the section surrounding the sprocket.

Experimental determinations are described in which the magnitude of centrifugal tensions, on a special stand of statistical conditions, is carried out with the help of the imitation of the centrifugal forces by means of tensioned threads, the tension being achieved by weights attached to them corresponding to the tension described. The tests were carried out at angles of envelopment of 180 and 220°. The tension of the chain was determined by a dynamometer of the "Alligator" type. The results of the trials are recorded in a curve, showing the dependence of the magnitude of the centrifugal tension on the speed (of the transmission). The formulas derived in this work for the centrifugal tension of a thread when movement on its surface is steady have long been known and are explained, for instance, in the Course on Theoretical Mechanics, by Lamb [Vol. **2**, 1935].

F. M. Kurovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1464. Zalessky, N. G., The use of the Zhukovsky lever in the measurement of reactions in kinematic mechanical couples (in Russian), Thesis, Dnepropetr. Metallurg. Inst., Kharkov, 1956; Ref. Zh., Mekh. no. 11, 1956, Rev. 7246.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1465. Pogosov, G. S., The problem of variations with conditions of non-free bonds (in Russian), Collection of articles vses. zaoch, politkh. in-ta no. 9, 70-83, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5695.

Author holds that the classical equations of Lagrange relative to the problem being examined have to be corrected, and puts forward instead his own equations [4]. The reasoning of the author is at fault. I. S. Arzhanykh

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1466. Szul'gin, M. F., The integration of equations in dynamics with multiple bonds (in Russian), *Trudi' Sredneaz. in-ta* no. 54, 115-130, 1954; *Ref. Zh. Mekh.* 1956, Rev. 5694.

Dynamic systems according to the theorems of Poisson and Hamilton-Jacobi are examined. Poisson's theorem and some of its modifications are proved with the help of Louiville's amplification, while the theorem of Hamilton-Jacobi is proved if free bonds are present. The impossibility of applying a theorem of this type for other systems is noted. I. S. Arzhanykh

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1467. Makarov, A. I., The importance of the work of Professor M. E. Zhukovsky in the study of the rotation of textile spindles at working speeds (in Russian), *Nauch. issled. tr. Mosk. tekstiln. in-ta* **15,** 21-32, 1955; *Ref. Zh. Mekh. no.* 11, 1956, Rev. 7220.

A recapitulation of the contents of Professor Zhukovsky's work on "The elastic shaft of a Laval turbine, and shafts with rocking bearings" [Coll. Wks. Vol. III, Moscow/Leningrad, 1949, pp. 523-537].

An investigation of the motion of a textile spindle whose center of gravity is above its support (step bearing). Data on spindle tests are presented. A. S. Petrov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1468. Kogan-Wolmann, G. I., The problem of accuracy in flexible-shaft drives (in Russian), *Trudi' Odessk. tekhnol. in-ta* **7,** 63-70, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7239.

Elementary systems of flexible-shaft drives are analyzed to determine the setting error of the follower of a flexible-shaft drive, and methods for reducing this error discussed. Methods of compensating the stiffness of the flexible shaft in alternate, bilateral torsion are examined. A. D. Nevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1469. Yoshimoto, I., Analysis of Hindley-Worm drive, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-159, 13 pp.

Paper examines reason for discrepancy between Buckingham's ["Analytical mechanisms of gears," McGraw-Hill, 1949, p. 276] and Yamamoto's ["Investigations on cone worm drive," Misc. Rep. Res. Lab. Prec. Mach. Tokyo Inst. Tech. 1946] results for the worm-wheel profile of Hindley or Cone enveloping worm gears, especially in view of agreement of methods in giving worm tooth profiles. Author shows both, in fact, lead to same result but Buckingham errs in stating "one-half of each side of the gear tooth will be the form produced by the hob at the central section where the lead angle is greatest and the other part by that end of the hob which has the highest pressure angle and also has the lowest lead angle." In fact, half the worm-wheel tooth profile is given by the trace of that end of the hob which has the *lowest* pressure angle and the other half is not defined by the single trace for the central position but is given by the envelope of various traces.

Author's method is rather more convenient for calculation than Buckingham's or Yamamoto's. Preprint contains several confusing misprints. E. M'Ewen, England

1470. Riparbelli, C., An analytic form of the principle of maximum power, *J. aero. Sci.* **24,** 4, p. 307, Apr. 1957.

Servomechanisms, Governors, Gyroscopics

(See also Revs. 1496, 1730)

Book—1471. Geyer, H., and Oppelt, W., Automatic control in society compared with automatic control in technology [Volkswirtschaftliche Regelungsvorgänge, im Vergeich zu Regelungsvorgängen der Technik], München, R. Oldenbourg, 1957, 143 pp. DM 13.50.

Book is a collection of papers contributed to the March 3 and 4, 1955 meetings in Essen, Germany sponsored by the Haus der Technik and the automatic control committee of the VDI and VDE German engineering societies. The book begins with a paper by W. Oppelt on the fundamentals of automatic control. H. Geyer follows this with mathematical descriptions of the social-economic feedback systems of Ricardo, Keynes, and Tustin. The system of Tustin involves dead time as well as derivative. Geyer applies frequency response techniques to the problem of the stability of Tustin's elementary model. C. Föhl extends the models to higher-order economic systems with multiple loops. H. Tischner applies the Laplace transform approach to an elementary multiple-loop economic model. R. Henn considers the construction of models to fit observations. K. Förstner takes into account the discreet character of variables, such as money, by the construction of discontinuous models in which continuous variables such as time are treated as discontinuous. The book terminates with a paper by K. J. Lesemann on the use of computers in the study of economic systems.

In the introduction to this volume W. G. Waffenschmidt emphasizes that the present state of the world social-economic order makes the application of the scientific techniques of automatic control to economic models imperative. Reviewer feels that this book gives an excellent survey of what is known about this relatively new approach, to which servomechanism scientists and engineers have much to contribute.

R. Oldenburger, USA

1472. Huss, C. R., and Donegan, J. J., Tables for the numerical determination of the Fourier transform of a function of time and inverse Fourier transform of a function of frequency, with some applications to operational calculus methods, *NACA TN* 4073, 205 pp., Oct. 1957.

The functions $(1/z) \sin z \cos (2n-1)\, z$ and $(1/z) \sin z \sin (2n-1)z$, needed in obtaining numerically the direct and inverse Fourier transforms, were tabulated in the limits $1 \leq n \leq 50$, $0.00 \leq z \leq 2.50$ and $0.00 \leq z \leq 1.00$, respectively, in AMR **9,** Rev. 1704. In this paper, the tabulation has been greatly extended to the limits $1 \leq n \leq 100$, $0.00 \leq z \leq 2.10$ with $z = 0.01$ and $2.10 \leq z \leq 5.08$ with $z = 0.02$. These tables should be a valuable help for system analysis and operational calculus methods. Several examples for use of the method and of the tables are also given.

C. B. Ludwig, USA

1473. LeFevre, P. M., Development of the generalized phase diagram method, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-216, 36 pp.

The method is similar to the complex plots of Nyquist for determining the stability of feedback mechanisms. It appears simpler to use than those plots when the transfer function is given as a sum of fractions whose numerators and denominators are products of linear or quadratic factors. C. Ablow, USA

1474. Ulanov, G. M., Invariance to ε in linear combination automatic regulation systems, *Dokladi Akad. Nauk SSSR* **112,** 2, 253–256, 1957.

Conditions of absolute invariance with respect to perturbations in a combined open-loop and closed-loop control system are relaxed to those of variance within prescribed tolerance.

L. S. Dzung, Switzerland

1475. Sawaragi, Y., and Sunahara, Y., On a method of evaluation of the dynamical behavior of coordinated control system, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 465–469.

Authors study the linear stationary system $dx/dt = Ax + b\ (t)$ where x, $b(t)$ are real n-vectors and A is a real $n \times n$ matrix. If $\Phi(s)$ is the matrix of transfer functions whose elements by definition are equal to the Laplace transform $x_i(s)/b_j(s)$, then the above may be written as $x(s) = \Phi(s)b(s)$. An explicit formula for $\Phi(s)$ is obtained as follows. Let all eigenvalues of A be distinct and denoted by λ_k, $k = 1, \ldots, n$. Let e^k be an eigenvector of A and f^k an eigenvector of A' ($'$ = transpose) corresponding to λ_k. Let B^k be an $n \times n$ matrix whose elements are e_i^k/f_j^k. Then $\Phi(s) = \Sigma_k B^k/(\lambda_k - s)$.

A numerical example illustrating the necessary computations is included. Reviewer remarks that $\Phi(s)$ may be found also by the block-diagram or signal-flow graph methods, which do not require knowledge of the eigenvalues of A.

R. E. Kalman, USA

1476. Levitan, S. A., Determination of the optimum controller parameters in control systems for objects with lag, *Automation and remote Control (USSR)* **12,** 9, 947–951, Sept. 1956 (Consultants Bureau Translation *Avtomatika i Telemekhanika* **12,** 9, 853–857).

Author uses delay-plus-lag representation of a passive process with proportional-plus-integral control [cf. J. C. Ziegler and N. B. Nichols, "Optimum settings for automatic control," *Trans. ASME* **64,** 8, 759–768, Nov. 1942; K. L. Chien, J. A. Hrones, and J. B. Reswick, "On the automatic control of generalized passive systems," AMR **5,** Rev. 2770]. Paper presents oscillograms obtained from an analog computer, showing closed-loop transient response of the system to a step input for various lag-to-delay ratios. Example in paper illustrates use of these oscillograms in selecting best controller settings for a given physical process.

T. P. Goodman, USA

1477. Stobakov, S. A., Application of the concept of phase period to investigation of systems of automatic control (in Russian), Tr. 2-go Vses. soveshch. po teorii avtomat. regulirovaniya, vol. 1. Moscow-Leningrad, Izd.-vo Akad. Nauk SSSR, 1955, 149–165; *Ref. Zh. Mekh.* 1956, Rev. 4980.

General views are stated relating to the application of geometric considerations in a phase period for the investigation of behavior of a dynamic system. Yu. I. Neimark

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1478. Tsypkin, Ta. Z., Frequency method of investigating periodic conditions of relay systems for automatic control (in Russian), In memory of A. A. Andronov, Moscow, Izd-vo Akad. Nauk SSSR, 1955, 383–410; *Ref. Zh. Mekh.* 1956, Rev. 4994.

It is shown that the equation for finding the periodic motion of a relay system and the characteristic function, the disposition of the roots of which relative to the unit circle governs the stability of motion, may be expressed by values of the transmission coefficient $K(p)$ on an imaginary axis.

Author proposes simple graphical methods which enable the stability of the simplest symmetrical self-oscillation and constrained oscillation to be found and investigated, leading to a scheme for examining the periodic motion of the so-called characteristic of the relay system in order.

$$W(T(= -\frac{4k}{\pi} \sum_{m=1}^{\infty} Re\ K\left((2m-1)\frac{\pi}{T} j\right) + \frac{j\ \mathrm{Im}\ K}{2m-1}\left((2m-1)\frac{\pi}{T} j\right) \qquad [1]$$

and for the investigation of the stability, the curve

$$K^*(j\omega) = -\sum_{-\infty}^{+\infty} K\ \left[(\omega + (2m-1)\ \omega 0)\ j\right]$$

It is then shown that the form of the periodic motion can also be obtained starting from the function $K(i\omega)$. A comparison is made of the precise results and the results obtained by the method of harmonic balance. In this it is shown that Goldfarb's known construction, which is applied to the relay system, is obtained from the author's graphical construction if, in the corresponding expression for the characteristic of the relay system [1], only one first term is retained, and for the explanation of the stability it is limited by certain necessary conditions. These results enable it to be seen clearly whether the method of harmonic balance and the various multiple methods of actual investigation connected with it are or are not applicable to investigation of the simplest symmetrical motion of a relay system.

Yu. I. Neimark

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1479. Sokolov, T. N., The synthesis and physical embodiment of electromechanical servo systems (in Russian), Trans. 2nd All-Soviet Conference on the Theory of Servomechanisms, Vol. 2, Moscow/Leningrad, Akad. Nauk SSSR, 1955, 163–183; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7214.

Author points out that, in the majority of works on the theory of servomechanisms, the problem of synthesis is reduced to calculating the optimum values of the coefficients of the transmitting functions. It is, however, also necessary to calculate the values of the real parameters of the system, the construction of which determines the aforementioned coefficients. Unless this second problem is solved, the optimum coefficients may prove to be physically unrealizable. The conditions for the physical embodiment of servomechanisms are then formulated and a method suggested for the synthesis of electromechanical servo systems. Author starts from the required quality of transmission, on the basis of a particular arrangement of the roots of the characteristic equation and the characteristic quality of the established accuracy of the servo system. The following cases are examined: (1) a system with rigid feedback; (2) a system with a passive differentiating link; (3) a system with a passive integrating and differentiating link; (4) a system with flexible feedback according to the amplification; (5) a system with inertia amplification and flexible feedback according to the acceleration; (6) a system with active integrating and differentiating links and flexible feedback.

E. P. Popov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1480. Popovsky, A. M., On a particular solution of the problem of I. N. Voznesensky for control systems intercoupled by high-order quantities (in Russian), Trans. 2nd All-Soviet Conference on the Theory of Servomechanisms, Vol. I, Moscow/Leningrad, Akad. Nauk SSSR, 1955, 465–478; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7200.

Linked-control systems are examined in which the controlled elements are described by equations of higher than first order. In such case, completely automatic control is not obtained, but by introducing additional linkages a "discrete decoupling" of the control processes of each controlled element is obtained at specific frequencies. The control systems themselves are assumed to be ideal. The quality of control is assumed to be determined by the degree of stability of the system. The case of control systems with two intercoupled quantities is particularly examined.

E. P. Popov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1481. Solodovnikov, V. V., Problems of quality and dynamic accuracy in the theory of servomechanisms (in Russian), Trans. 2nd All-Soviet Conference on the Theory of Servomechanisms, Vol. 2, Moscow/Leningrad, Akad. Nauk SSSR, 1955, 7–27; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7201.

The fundamental problems of the theory of servomechanisms are formulated as well as the problems of quality of control and dynamic accuracy. A brief survey is given of the analytical and synthetical problems involved, and the principles of solution of such problems are indicated. I. V. Pyshkin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1482. Popovsky, A. M., Plotting the working range of systems controlling intercoupled values (in Russian), Automation of production processes, Moscow, Akad. Nauk SSSR, 1955, 34–67; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7208.

The methodology is developed of the synthesis of control systems with a number of controlled values. For a particular case the characteristics of which are determined either by a system of differential equations or by experimental data, the control parameter values are sought which insure the required values of the control characteristics: response time, static and dynamic error, coefficient of over-control. Author restricts consideration essentially to the case of only two parameters. In this case, the stability range and the range of prescribed stability are first determined by D-analysis. Author recommends for this purpose his own graphical method founded on the use of vector diagrams. The method is as equally applicable to the case of an object defined by a given system of differential equations as to the case of definition by frequency characteristics. From the resulting range of prescribed stability, the region is isolated, corresponding to the parameter values, which will insure the prescribed degree of static error and over-control. The matter is determined by direct calculation for a number of points in the region.

I. B. Chelpanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1483. Ivashnenko, O. G., The application of invariance conditions to servomechanisms with executive elements of restricted power (in Ukrainian), *Dopovidi Akad. Nauk USSR* no. 5, 429–434, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7204.

A follow-up system is investigated in which the executive element has a Z-characteristic with a sloping section. The tuning of such a system for invariance conditions completely eliminates all errors only in the presence of an inertialess amplifier and systematic accelerations not exceeding a particular value determined by the range of linearity of the executive element. In the presence of inertia in the amplifier, complete elimination of errors in a linear system requires the introduction of a correction signal for the third derivative of the perturbation incorporating the impulse function. In such case, a system with restricted power of the executive element is unable to completely eliminate errors. To reduce the degree of error, author suggests the use either of a smoothing element or an intensifying arrangement. Expressions are given for calculating the latter. The paper contains misprints.

A. S. Alekseev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1484. Ulanov, G. M., Some problems of dynamic accuracy in nonlinear automatic control systems and servomechanisms for the case of perturbations of limited module (in Russian), Trans. 2nd All-Soviet Conference on the Theory of Servomechanisms, Vol. 2, Moscow/Leningrad, Akad. Nauk SSSR, 1955, 472–483, *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7203.

A brief survey is made of the investigation of the dynamic accuracy of control systems and servomechanisms on the assumption of perturbing forces of limited module.

The problem is examined of determining the maximum possible deviation in control systems incorporating a relay element and a nonlinear element having a saturation region in the presence of perturbing forces of a limited module.

A. V. Khramoi

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1485. Block, Z. Sh., The calculation of governing parameters from given control conditions (in Russian), Trans. 2nd All-Soviet Conference on the Theory of Servomechanisms, Vol. 2, Moscow/Leningrad, Akad. Nauk SSSR, 1955, 117–144; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7202.

The indications of monotony as well as the conditions for over-control and speed response are stated on the basis of the roots of the characteristic equation under starting conditions corresponding to load-shedding or detuning of the controlling element. The manner of determining these values is illustrated on a series of examples.

Using these results, as well as the formulas for calculating the static deviation, it is possible to determine the distribution of the roots at which particular conditions for the quality of control will be fulfilled. A method is proposed for calculating the parameters of a servomechanism, enabling the required distribution of the roots to be obtained and applicable to a wide range of static and astatic systems. Calculation formulas are presented for a number of typical arrangements. A. A. Fel'dbaum

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1486. Dorr, J., Simplified calculation of the quadratic control area (in German), *Regelungstech.* **5**, 4, 114–118, 1957.

The quadratic control area is defined as the quantity

$$F_q = \int_0^\infty [y(T) - y(\infty)]^2 \, dt,$$

where $y(t)$ is the response of the controlled system due to unit step input. F_q is a criterion for the quality of the control and should be minimal. It is shown by aid of a mathematical derivation that F_q can be expressed as an integral in the complex plane, which can be calculated by evaluating the residues in the poles.

The position of the poles is found by solving an algebraic equation of order $(n-2)/2$ (n even) or $(n-1)/2$ (n odd), where n denotes the order of the linear differential equation governing the controlling process. A. I. van de Vooren, Holland

1487. Reethof, G., Application of the analog computer to predict dynamic performance in typical hydraulic circuits, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-97, 8 pp.

Instabilities encountered in the development of a hydraulic booster system were duplicated in the solution from electronic analog computer. Changes developed from computer solution were

successful in eliminating trouble. An important factor was the inclusion in the equations of nonlinearities of control-valve port opening versus displacement.

Reviewer concurs in author's statement that valid results depend upon a realistic mathematical formulation of the system characteristics. J. A. Harder, USA

1488. Jursik, J., Kaiser, J. F., and Ward, J. E., A dual-mode damper-stabilized servo, *Trans. ASME* **79,** 3, 473–479, Apr. 1957.

The highly oscillatory response of an inertia-damper stabilized servo to large step inputs can be improved greatly by changing, for large error, the coupling torque between the damper and the drive motor. This paper presents the results obtained from an experimental model and an analog computer study of the dual-mode damper-stabliized servo. For large step inputs, this dual-mode method of operation resulted in a reduction of settling time by a factor of 5.8 and reduction of peak overshoot by a factor of 200 as compared with single-mode operation.

From authors' summary

1489. Vasu, G., Experiments with optimalizing controls applied to rapid control of engine pressures with high-amplitude noise signals, *Trans. ASME* **79,** 3, 481–488; Apr. 1957.

Optimalizer control principles were applied to the control of a flight-propulsion system. The control system described metered the fuel flow to an engine in such a manner as to cause the engine to seek a maximum pressure. Experimental data are presented illustrating the control behavior for a range of flight conditions, for various control settings such as gain and integral time constant, for various amounts of filtering, and so on.

From author's summary

1490. Andrew, G. M., Automatic control with artificial inertia, *J. aero. Sci.* **24,** 4, 306–307, Apr. 1957.

The behavior of a second-order system with built-in artifical inertia is analyzed and illustrated on the records from the analog computer. From author's summary

1491. Hart, C. E., Wenzel, L. M., and Craig, R. T., Experimental investigation of temperature feedback control systems applicable to turbojet-engine control, *NACA TN* 3936, 56 pp., Mar. 1957.

Two basic temperature feedback control systems were investigated as means of controlling tailpipe gas temperature of a turbojet engine during transient operation in the high-speed region.

A proportional-plus-integral control in a temperature-fuel-flow control system provided satisfactory transient response to a desired step increase in temperature. For a temperature-exhaust-nozzle-area control system, it was necessary to add nonlinear components to the basic proportional-plus-integral control to provide satisfactory temperature response during transients.

Several criteria for selecting control-loop parameters for optimum transient response were investigated. For the temperature-fuel-flow control system, minimization of time integrals of either the square or absolute values of temperature error seemed to be more selective than other criteria in determining optimum control-loop parameters. For the temperature-area control system, none of the criteria proved adequate in selecting optimum loop gain, but they did indicate a choice of control integral time constant.

Engine dynamics in the high-speed region were determined by synthesizing transfer functions to match experimental frequency-response data. Over the control operating region investigated, engine temperature-fuel-flow dynamics could be satisfactorily represented by first-order terms and a dead time. Similarly, engine temperature-area dynamics could be represented by first-order terms and a dead time.

From authors' summary

1492. Boronkay, A. D., Csupor, I., Damokos, T., Demjen, Z., and Juhasz, E., The electronic, controlling- and automatic error-detecting system of an isothermal crystallurgical device (in Hungarian), *Mérès ès Automatika* **4,** 10, 304–310, Oct. 1956.

Authors deal with the electronic circuits and their function in the automatic isothermal crystallurgical apparatus constructed by them. They explain the principles of the automatic observation of the disturbances of the apparatus and describe the devices already realized, automatically eliminating some often-occurring defects.

From authors' summary

1493. Frith, J. G., Hydraulic accumulators in heavy industry, *Proc. Instn. mech. Engrs.* **170,** 5, 182–206, 1956.

Paper describes the principal features of the weight-loaded and gas-loaded types of hydraulic accumulator, together with the applications where they are of particular service.

A distinction is drawn between those gas-loaded accumulators where the gas and the pressure liquid are separated, and those where they are directly in contact with each other, and the separated type is further subdivided according to the method of separation.

The appropriate control gears for the various types of accumulator are described and special reference is made to the particular problems associated with the control of the nonseparated type of gas-loaded accumulator.

The normal method used in calculating the volumetric ratio between the compressed gas and the usable liquid in gas-loaded accumulators is quoted, together with the effect of special conditions upon the amount of pressure variation. Figures are also given to show the effect of temperature changes upon the working pressure in this type of accumulator, and the normal maximum allowable working pressure in the nonseparated type.

From author's summary

1494. Jarre, G., Dynamical property of a mechanical velocity control device (in Italian), *Atti Accad. Sci. Torino Cl. Fis. Mat. Nat.* **90,** 552–562, 1955–1956.

Vibrations, Balancing

(See also Revs. 1459, 1462, 1467, 1523, 1597)

Book—1495. Morrill, B., Mechanical vibrations, New York, N. Y., The Ronald Press Co., 1957, vii + 262 pp. $6.50.

An elementary text for undergraduate engineering students who have not had comprehensive courses in mathematics and mechanics. Review topics such as kinematics of relative motion and energy methods are included, and such elementary mathematical subjects as exponential functions, partial differentiation, and linear differential equations with constant coefficients are discussed. A detailed treatment of the free and forced vibrations of the viscous damped single-degree-of-freedom system is given. For more complex systems, the Holzer numerical method is developed and the simpler applications of Rayleigh's method are used. Later in the book a brief chapter is devoted to Lagrange equations. Vibrations in uniform strings, beams, and bars are treated by mode superposition methods. Book concludes with brief discussions of electrical-mechanical analogs, the mobility method, and the operational-type analog computer.

D. E. Hudson, USA

1496. Kryzhanovsky, O. M., Determination of significant regions of coefficients of a differential equation from the limit of the maximum frequency of self-induced oscillation in a control system (in Ukrainian), *Dopovidi Akad. Nauk USSR* no. 4, 328–332, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7194.

In automatic control systems described by linear equations with invariant coefficients it is sometimes necessary to eliminate the

possibility of self-induced oscillation, of a frequency exceeding some predetermined limit b.

A method of solution of a problem of this kind, by analysis of the coefficients of the equation, is suggested.

A known theorem is stated: in order that all the roots p of a polynomial or quasi-polynomial $H(p)$ shall be on the left of the imaginary axis, it is necessary and sufficient that all roots of the polynomial $H(iz)$ shall be located in the upper half-surface. If, however, the system is required to be stable and not at the same time have a natural frequency of oscillation greater than or equal to b, it is necessary and sufficient that all the roots of the characteristic equation $H(p) = 0$ with real coefficients shall be located above the straight line $Imp = -b$ in the plane of the complex variable p; and consequently, that the stability conditions shall be satisfied in the plane of the complex variable p' rotated through 90° with reference to the point $(0, -ib)$ in such manner that the straight line $Imp = -b$ shall coincide with the imaginary axis of the plane p'.

The transformation in accordance with this conception is effected by substituting the variables $p = z - ib$ in the characteristic equation $H(p) = 0$, i.e., $H(z - ib) = P_1(z,b) + iQ_1(z,b)$.

The next stage consists in analyzing the polynomials $P_1(z,b)$, $Q_1(z,b)$ by the usual methods of stability analysis. Author is of the opinion that the most effective of such methods is that of Yu. I. Neumann ["Stability of linearised systems," Leningr., VVIA, 1949], in which the requirement that $b \to 0$ leads to a condition of aperiodicity, as suggested by the author. Examples are given.

V. O. Kononenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1497. Li, W.-H., Graphical solution of equations of vibrations, *Proc. Amer. Soc. civ. Engrs.* **83,** EM 4 (*J. Engng. Mech.*), Pap. 1412, 18 pp., Oct. 1957.

An analysis of vibratory systems governed by two simultaneous first-order ordinary differential equations is presented using a graphical technique. The step-by-step graphical integration is similar to Jacobsen's general method [AMR **6,** Rev. 2124] of solving second-order ordinary differential equations. The approximate solution consists of the end-points of a series of circular arcs. Equations are given for the location of arc centers and radii. Method is demonstrated by several applications to hydraulic systems with nonlinear damping force and arbitrary forcing function.

Reviewer believes technique is valuable for obtaining rapid approximate answers as well as more quantitative ones.

R. B. Grant, USA

1498. Kobori, T., and Minai, R., On the stability of certain nonlinear forced vibrations, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 499–502.

The language usage and organization of this paper makes it difficult to follow. It appears to be concerned with motions in which the displacement variable reaches critical values at which the motion becomes unstable. The paper seems to be an interesting piece of work and anyone working the field probably would find it worthwhile to patiently decipher its contents.

M. G. Scherberg, USA

1499. Shimizu, T., Forced vibrations with Coulomb damping, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 503–506.

A conventional one-degree-of-freedom second-order motion is studied in which only Coulomb damping is admitted and the forcing function is harmonic. The range of parameters and initial conditions selected are such as to give both the "stop" and "non-stop" motions. The "stop" motions are those in which motion stops during a time interval when the combined forces are equal to or less than the maximum Coulomb motion friction. The effect of Coulomb static starting friction is not taken into account in the stop-motion cases. Detailed solutions are given.

M. G. Scherberg, USA

1500. Loitsianskii, L. G., Free and forced vibrations for a quadratic resistance law and an intermediate law between the linear and quadriatic laws, *Inzhener. Sbornik, Akad. Nauk SSSR* **18,** 139–148, 1954.

Free undamped vibrations under the action of nonlinear positional forces have been discussed by Ya. G. Panovko, title source **13.** 113–122, 1952 and N. K. Kulikov, AMR **7,** Rev. 416. They replaced the nonlinear characteristic of resistance by a rectilinear segment or a system of such segments. In the present paper the same method is applied to free damped and forced vibrations for laws mentioned in the title of the paper.

E. Leimanis, Canada

1501. Di Taranto, R. A., Natural frequencies of nonuniform beams on multiple elastic supports, ASME Fall Meet., Hartford, Conn., Sept. 1957. Pap. 57-F-5, 7 pp.

Myklestad's method for calculating natural frequencies and modes for bending beams is extended to include the effect of rotary mass moment of inertia and the effect of torsionally and linearly elastic supports. Tables are presented which facilitate the calculations. Procedure is well suited for an electronic digital computer.

A. I. van de Vooren, Holland

1502. Schilhansl, M. J., Bending frequency of a rotating cantilever beam, ASME Fall Meet., Hartford, Conn., Sept. 1957. Pap. 57-F-6, 3 pp.

For the case of a uniform untwisted cantilever beam attached to a rotating hub, the lowest natural frequency in bending is determined as function of the ratio of hub radius to blade length, of the angular velocity ω and of the setting angle ψ between the blade and the rotational velocity. Result is obtained by integration of the differential equation substituting an estimated deflection curve in the load terms. Procedure may be repeated with the iterated deflection curve.

Reviewer remarks that also for a nonuniform beam the result can be written as

$$\nu^2 = \nu_0^2 + (K - \sin^2\psi)\omega^2 + \text{terms of order } \omega^4,$$

where ν is the natural frequency at angular velocity ω, ν_0 the natural frequency for the nonrotating beam, and K is a quantity which depends upon the mass distribution and upon the mode to be assumed for the nonrotating beam. K can be determined as a quotient of integrals (analogous to the Rayleigh quotient for ν_0^2).

A. I. van de Vooren, Holland

1503. Targoff, W. P., The bending vibrations of a twisted rotating beam, Proc. third Midwestern Conf. solid Mech., Univ. of Mich., Apr. 1957, 177–194.

Matrix method is employed to compute the modes and frequencies of twisted rotating beams. The calculations are well suited for programming on a computing machine of the IBM C.P.C. type. Numerical results are given for comparable cases with experimental results, which are in full accordance with them. Significant graphs for the calculated frequency, flatwise and edgewise deflections, and bending moment are given.

G. Sestini, Italy

1504. Minhinnick, I. T., The theoretical determination of normal modes and frequencies of vibration, *AGARD Publications Rep.* 36, 29 pp. + A-xi + B-iii + C-iv, Apr. 1956.

Various methods are discussed for the determination of modes and frequencies for purely flexural or torsional vibrations of beams in which the effects of shear deflection, shear lag and rotary inertia are neglected for the flexural vibrations and in which the

effect of section warping for constrained torsion is neglected in the torsional vibrations.

Author discusses some of the relative advantages and disadvantages of methods of (1) Holzer-Myklestad, (2) Stodola, (3) numerical integration and collocation, (4) Morris discrete mass, (5) Rayleigh-Ritz, (6) complementary energy, and (7) collocation with assumed modes. Comparison is made by means of a numerical evaluation for the first three mode frequencies of a tapered beam.

Equations are cited for the coupled flexure-torsion of beams, based on the concept of a flexural axis. The escalator method is discussed in connection with the modes and frequencies for a complete aircraft.

Paper contains an appendix on Duncan displacement functions and the escalator method. A large bibliography is presented.

M. V. Barton, USA

1505. Rao, C. V. J., and Kantham, C. L., Natural frequencies of rectangular plates with edges elastically restrained against rotation, *J. aero. Sci.* **24,** 11, 855–856, Nov. 1957.

Authors use Rayleigh-Ritz method for subject problem and give variation of frequency with elastic restraint for a square plate.

D. Young, USA

1506. Hoppmann, W. H., II, and Magness, L. S., Nodal patterns of the free flexural vibrations of stiffened plates, *J. appl. Mech.* **24,** 4, 526–530, Dec. 1957.

Experimental frequencies and nodal patterns are given for normal modes of square plate with orthogonally placed stiffeners. Results are compared with theory. Compounding of modes is illustrated.

R. N. Arnold, Scotland

1507. Grigolyuk, E. I., Vibrations of a slanting circular cylindrical plate undergoing finite deflection (in Russian), *Prikl. Mat. Mekh.* **19,** 3, 376–382, 1955.

Vibrations of a curved panel (a rectangular section of a cylindrical shell) are considered here. Edges of the panel are pinned but free to rotate. Equations for vibration of the plate, modified to allow for initial curvature, are solved by Galerkin's method. Author saves two terms of the resulting series for the deflection, then writes and solves approximately a pair of nonlinear differential equations for the two coefficients involved. The corresponding problem for the static case was treated by Mushtari and Sviersky [title source **17,** 755–760, 1953], whose solution was closely followed in analogous form by the present author.

R. E. Gaskell, USA

1508. Wassermann, E. B., The free oscillations of loaded elastic circular arches and rings (in Russian), Thesis, Latvian University, Riga, 1956; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7796.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1509. Kruszewski, E. T., Kordes, E. E., and Weidman, D. J., Theoretical and experimental investigations of delta-wing vibrations, *NACA TN* 4015, 11 pp., June 1957.

The results of some theoretical and experimental investigations of delta-wing vibrations are discussed.

Nodal-line patterns and frequencies of a 45° built-up thin-skin delta-wing specimen obtained experimentally are compared with those calculated by two analytical methods—the idealized-structure type of method as described by Levy and a limited-deformation type of method proposed by Stein and Sanders. It is shown that when the effects of transverse shear are included in the Levy approach the agreement between calculated and experimental frequencies is exceptionally good.

Experimental nodal-line patterns and frequencies for a 60° thick-skin delta wing are also shown.

From authors' summary

1510. Bellenot, C., Dzung, L. S., and Erni, E., Determining the critical speeds of fast-running shafts, *Brown Boveri Rev.* **44,** 4/5 234–238, Apr./May 1957.

1511. de Pater, A. D., Vibration of railway vehicles (in French), *Appl. sci. Res. (A)* **6,** 4, 263–316, 1957.

1512. Bagchi, R. M., On an extension of Kar formula of minimum bowing pressure, *Indian J. theor. Phys.* **4,** 1, 15–19, Mar. 1956.

Kar formula for minimum bowing pressure [title source **2,** p. 46, 1954] is extended by calculating the frictional force more rigorously. The formula thus obtained satisfactorily explains both the straight portion (at high velocities) and the upward bend (at low velocities) of the $P_{min} - V$ curve.

From author's summary

1513. Savin, J. M., Postol'nik, Yu. S., and Shevels, V. M., The dynamic equation relating to an elastic or elastic-tensile strand of variable length (in Russian), *Prikl. Mekh.* **1,** 1, 36–40, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6210.

An investigation is made of the longitudinal oscillation of a load, suspended on an ideal elastic or elastic-tensile strand to a cylinder, revolving at a given speed around an immovable axis. By setting limits to the problem, when the weight of the strand is not large by comparison with the load, authors deduce a differential equation for the oscillating movement of this load.

N. V. Zvolinskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1514. Molyneux, W. G., Supports for vibration isolation, *Aero. Res. Counc. Lond. curr. Pap.* 322, 8 pp. + 11 figs., 1957.

Spring arrangements are described that provide flexible supports of very low stiffness for a limited range of movement. They are suitable as supports for vibration isolation provided the levels of vibration are not too large.

Some particular applications of the arrangements for vibration isolation and in other fields are discussed.

From author's summary

1515. Gorelik, V. M., An applied vibrational calculation of shock-absorbers composed of rubber—metal (in Russian), *Trudi N.-i. in-ta rezin. prom-sti.* no. 2, 14–26, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6306.

The elementary knowledge on the oscillations of a system with one degree of freedom in the presence of viscous resistance is cited. In determining the natural frequency it is proposed to introduce in the customary formula the modulus of elasticity, derived not from static but from the dynamic experiments; this proposal contradicts the idea of obtaining the formula from the accepted elastic-viscous system. It appears that for constructional, shock-absorbing rubber, the logarithmic decrement of damping is found in the range of 0.3 – 0.8. Formula (6) contains an inaccurately calculated coefficient.

Ya. G. Panovko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1516. Ivanov, Yu. V., On the question of selection of the magnitude of the limiting moment passed on to the torsional vibration damper (in Russian), Avtomobil'. Moscow, Mashgiz, 1955, 42–58; *Ref. Zh. Mekh.* 1956, Rev. 6201.

Considerations are expressed regarding the choice of stiffness of the springs placed round the periphery of the driving disk of an automobile clutch. A description is given of the construction of the apparatus and the method of carrying out the experiment to investigate the dynamic loading on the motorcar transmission in

relation to the stiffness of the selected springs. On the basis of the experimental data the deduction is made that the springs should be made as pliable as possible, and that the maximum torsional moment exerted by them should be equal to the moment on the wheel engagement, carried out at the maximum transmissive value of the transmission.

K. S. Kolesnikov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1517. Schraud, A., Power requirement of vibrator conveyors (in German), *Forsch. Geb. Ing.-Wes.* **23,** 1/2, 74-76, 1957.

Paper deals with material transport by means of vibratory chutes. Author determines optimum power requirements for transport in terms of frequency, amplitude, angle of material travel, and coefficient of friction. Paper contains curves needed for rapid calculation of derived equations and worked-out example.

J. M. DallaValle, USA

1518. Bolotin, V. V., Motion of a fluid in a vibrating vessel (in Russian), *Prikl. Mat. Mekh.* **20,** 2, 293-294, Mar.-Apr. 1956.

Based on earlier work of L. N. Sretenski [AMR **4,** Rev. 570] and N. N. Moiseev [AMR **6,** Rev. 1820], author discusses solutions of differential equations for series coefficients of the free surface of the fluid in the case of vertical harmonic oscillations of the vessel. Linear theory of ideal fluids yields differential equation of Mathieu, and in the instability domains of its solutions the coefficients of fluid oscillations grow exponentially with time, while experience shows stationary wave motion of finite amplitude. If linear damping due to viscosity is approximately taken into account, the domains of instability are reduced somewhat and, for small amplitudes of vessel vibrations, forced oscillations of the fluid disappear. In a numerical example, critical values for amplitudes of vessel oscillations are given.

A. Kuhelj, Yugoslavia

Wave Motion in Solids, Impact

(See also Revs. 1637, 1681)

1519. Hanin, M., Propagation of an aperiodic wave in a compressible viscous medium, *J. Math. Phys.* **36,** 3, 234-249, Oct. 1957.

The third-order differential equation describing the propagation of plane waves in viscoelastic solids or in compressible viscous solids is formally solved by operational methods. However, even for simple initial and boundary conditions the resulting Mellin inversion integral cannot be expressed in terms of known tabulated functions. The particular case of the disturbance caused by an impulse (Dirac pulse) applied at one boundary is investigated; several series and asymptotic expansions suitable for evaluating the resulting integral over different ranges of the variables are given.

Results are plotted for a representative wide range of the variables (expressed in dimensionless form); the graphs show that "the effect of viscosity is thus dispersion, rather than gradual annihilation, of the wave", as the reduction in the maximum amplitude of the wave with time is accompanied by a continuous spreading in space of the region of main disturbance.

G. Sved, South Australia

1520. Alekseev, A. S., Laws of wave propagation in an inhomogeneous medium (in Russian), *Doklady Akad. Nauk SSSR* (N.S.) **103,** 6, 989-992, Aug. 1955.

Applying the method of stationary phase to evaluate a transform solution, author shows that, for a half-space with variable shear modulus, an incident wave is accompanied by strong reflected waves and is propagated with a speed larger than in case of a homogeneous half-space.

G. Herrmann, USA

1521. Knudsen, W. C., Propagation of a pressure transient in a two-layer, liquid model, *J. acoust. Soc. Amer.* **29,** 8, 918-924, Aug. 1957.

Pressure transient propagation in a surface layer over a deep bottom layer is investigated with respect to group velocity, variation with depth and rate of amplitude decay which was found to be r^{-2} within experimental error. The results are in general agreement with a theory developed by C. L. Pekeris [*Geol. Soc. Amer. Mem.* **27,** 1, 1948].

F. E. Borgnis, USA

1522. Severy, D. M., and Mathewson, J. H., Technical findings from automobile impact studies, *SAE Trans.* **65,** 70-83, 1957.

1523. Schuler, S. C., The packaging of electronic equipment, *J. roy. aero. Soc.* **61,** 557, 335-344, May 1957.

The problems involved in the packaging of Service radar equipment are reviewed. Information on shock testing techniques, instrumentation and a design procedure for cushioning are given, together with some examples of current packaging methods used by the Ministry of Supply's Radar Research Establishment, Malvern, Worcs. The paper is based on a lecture given to the Royal Aeronautical Society, Gloucester and Cheltenham Branch, in December 1954.

From author's summary

Elasticity Theory

(See also Revs. 1513, 1555, 1574, 1614, 1624, 1635, 1822)

1524. Gordon, S. A., How wrong can elastic constants be? *Prod. Engng.* **29,** 1, 68-71, Jan. 1958.

The effect of variations in the elastic constants, tension and shear moduli and Poisson's ratio, on design equations is evaluated. Among the equations analyzed are those for an edge-loaded plate, cylinder in torsion, and column buckling. Article serves to review the lack of necessity of extreme accuracy in determining elastic constants for design criteria. For example, if there is a change of 33% in Poisson's ratio the buckling stress for a cylinder in torsion varies only 6%, and the buckling stress of an edge-loaded plate varies only 8%.

Author states that Poisson's ratio varies from 0.30-0.40 at low strains up to 0.50 for high strains. Reviewer believes that if Poisson's ratio is to be considered an elastic constant, then the plastic contribution to an experimental measurement should be identified. The philosophy underlying considerations of the elastic moduli should also be used in discussing Poisson's ratio.

A. D. Schwope, USA

1525. Goded, F., Spherical symmetry in the theory of elasticity, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-119, 5 pp.

Author considers elastic problems in which the shearing stresses tangent to the surface of spheres around the origin vanish. A class of solutions, in spherical coordinates, can be generated by certain stress functions satisfying a second-order linear partial differential equation. Product solutions of this equation involve trigonometric and hypergeometric functions.

There is some analogy to Airy's stress function for plane problems and to the stress functions for axisymmetric problems. However, the author does not touch on the completeness problem, and his stress functions are of a rather restricted type. The term "spherically symmetric" for the class of problems considered by the author is misleading. There is no spherical symmetry in the ordinary sense.

W. Noll, USA

1526. Boley, B. A., A method for the construction of fundamental solutions in elasticity theory, *J. Math. Phys.* **36,** 3, 261–268, Oct. 1957.

Elastic displacement, stress, etc., in a given body, due to a concentrated force is to be found (Green's function G_1). Body is seen as embedded in a larger body for which the Green's function—G_2—is known. Then surface forces must be removed, this being expressible in integrals of G_1. Resulting integral equation— for G_1—is basis of paper's method. Solution is proposed by the iteration process of integral equations, also by a successive approximation scheme based on iteration plus successive improvement of the G_2, equivalent to improved choice of the larger body. Mindlin's problem of interior force in semi-infinite solid is used to illustrate method, larger body being infinite. First step of improvement disposes of about half of total required.

J. N. Goodier, USA

1527. Nomachi, S., On one method for solving three-dimensional stress problems by means of finite Fourier transformation—simply supported rectangular plate with any thickness, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 7–11,

Author solves problem of thick rectangular plate loaded on its upper and lower faces, and simply supported on its four sides, with exact elasticity theory. Method used is that of finite Fourier transforms. Results are in form of triple Fourier series. Numerical example is included for fiber stresses and stresses perpendicular to loaded surface when loading is a simple sine function on top surface. Effect of thickness is shown by comparison with conventional thin-plate theory.

H. J. Plass, Jr., USA

1528. Giesekus, H., Some remarks on Hanin and Reiner's "On isotropic tensor-functions and the measure of deformation" (in German), *ZAMP;* 8, 4, 303–306 (Short Notes), July 1957.

1529. Parkes, E. W., A comparison of the contact pressures beneath rough and smooth rafts on an elastic medium, *Géotechnique, Lond.* **6,** 4, 183–189, Dec. 1956.

An analysis is given for the contact pressures due to an arbitrary vertical loading applied to a large uniform elastic raft resting on an elastic medium. If Poisson's ratio for the medium is ½, the contact pressures are the same whether the under side of the raft be rough or smooth. For smaller values of Poisson's ratio, the contact pressures for a rough raft are slightly greater than those for a smooth raft, even though the displacement of the soil is less—a result which would not be predicted by an analysis based upon a coefficient of subgrade reaction.

From author's summary by R. E. Gibson, England

1530. Das, S. C., On the stresses in twisted composite spheres and spheroids, *Canad. J. Phys.* **35,** 7, 811–817, July 1957.

The components of stress are determined at the surface of separation of an elastic solid of spherical shape, composed of two concentric portions of different materials and subjected to a twisting moment. The computation is repeated for composite solids having the shape of prolate and oblate spheroids.

H. Deresiewicz, USA

1531. Ufliand, Ya. S., Contact problem in theory of elasticity for a circular-in-plan stamping die in presence of adhesion (in Russian), *Prikl. Mat. Mekh.* **20,** 5, 578–587, Sept.-Oct. 1956.

Author gives exact solution for mixed problem in theory of elasticity for semi-infinite solid. In the domain $Z = 0$, $r < a$, $[r = (x^2 + y^2)^{1/2}]$, the displacements u, v, w are prescribed, and in the domain $Z = 0$, $r > a$, the stresses σ_x, σ_y, τ_{xy} are given.

Application is made to contact problem of a rigid die, circular in plan, adhering to an elastic semi-infinite solid, the die subjected to an arbitrary system of external forces.

Significant simplification achieved in solution of problem is due to two circumstances: first, representation of the solution of equations in elasticity in the form of Papkovich-Neuber harmonic functions to which the author adds a fourth, enabling him to simplify formulation of boundary problems; and second, the main contribution, choice of toroidal coordinates admitting application of integral expansion of Mehler-Fok. This makes it possible to present distribution of stress on surface of contact in easily tabulated quadratures and to attain in closed and extremely simple form the relationship between the forces applied to the die and its displacements.

S. Sergev, USA

1532. Sokolovskii, V. V., Contact stresses on the wall boundary (in Russian), *Prikl. Mat. Mekh.* **20,** 5, 588–598, Sept.-Oct. 1956.

In this work is investigated plane ultimate equilibrium of a connected mass bounded by a curvilinear wall which is accompanied by a curve of rupture. Contact stresses are numerically determined and, in many cases, given in a simple closed form.

Author begins with the differential equations of equilibrium and condition at rupture. Transforming the components of stress referred to x and y coordinates to new variables, author obtains a fundamental system of equations of hyperbolic type which have two real families of characteristics. These characteristics are determined by known differential equations and have, in the $x - y$ plane, two isogonal families of lines intersecting each other at a known angle.

Application of formulas is made to specific case of normal pressure on the horizontal boundary. The real and ideal granular media are discussed. The combination of results in the paper indicates the influence of internal friction on the magnitude of the contact stresses along the contour of the wall.

S. Sergev, USA

1533. Durelli, A. J., and Kobayashi, A. S., Stress distributions around hydrostatically loaded circular holes in the neighborhood of corners, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-4, 6 pp.

Authors determine the stress distribution by photoelastic methods in the vicinity of a circular hole symmetrically placed near the corner of a square plate due to hydrostatic pressure applied over the boundary of the hole. Curves are presented showing the maximum shear stress variation along two lines through the hole center, one being normal to the plate boundary and the other passing through the plate corner. The variation of maximum stress along the plate edge and along the hole boundary is also shown. The range of ratio of hole radius to plate edge distance is from 0.50 to 0.91.

W. O. Richmond, Canada

1534. Koiter, W. T., An elementary solution of two stress concentration problems in the neighbourhood of a hole, *Quart. appl. Math.* **15,** 3, 303–308, Oct. 1957.

Author concludes that the stress concentration factor for a strip in tension with a central circular hole tends to 2 if the hole diameter approaches strip width. For the circular bar in tension with a spherical hole, he obtains the stress concentration factor as an expression involving Poisson's ratio as hole diameter approaches bar diameter and disagrees with C. B. Ling [AMR **9,** Rev. 1730], who gives one (1) for the factor.

Author applies elementary beam theory to a curved beam with a rapidly changing cross section, neglecting effects of shear and deflections, and approximates the beam depth. Reviewer believes some of these assumptions may be justified, but questions the omission of the moments produced by the deflections, particularly since deflections obtained by the author may be many times as large as the eccentricity represented by his stress concentration factors.

B. E. Gatewood, USA

1535. Schulze, H., Temperature stresses in pressure bridges (in German), *Dtsch. Eisenbahntech.* **5**, 10, 443–450, Oct. 1957.

1536. Singer, J., and Hoff, N. J., Effect of the change in thermal stresses due to large deflections on the torsional rigidity of wings, *J. aero. Sci.* **24**, 4, 310–311, Apr. 1957.

Experimental Stress Analysis

(See also Revs. 1601, 1605)

1537. Rao, C. L. A., and Sreevatsa, K., Simplification of harmonization of Laplace's equation by partial conformal transformation, *Proc. Soc. exp. Stress Anal.* **25**, 1, 155–160, 1957.

Laplace's equation is solved numerically for a U-shaped beam in bending. These results are combined with photoelastic results to obtain the principal stresses.

E. A. Davis, USA

1538. Mason, W. P., and Thurston, R. N., Use of piezoresistive materials in the measurement of displacement, force, and torque, *J. acoust. Soc. Amer.* **29**, 10, 1096–1101, Oct. 1957.

Paper contains general discussion of piezo-resistive effect and briefly describes gages made from germanium for the measurement of longitudinal and torsional strains. The chief advantage of such devices is the high gage factor attainable. However, the only calibration points presented are for the torsional transducer and these show a scatter of as much as 5–10%.

Reviewer wonders about stability of the effect in semi-conductor materials whose behavior is critically dependent on impurities, and feels that short discussion of this aspect might well have been included. M. J. P. Musgrave, England

1539. Hirschberg, M. H., Kemp, R. H., and Manson, S. S., Application of obliquely mounted strain gage to measurement of residual stresses in disks, *NACA TN* 4027, 7 pp. + 10 figs., Sept. 1957.

By using conventional wire strain gages, as principal stress gages, residual stresses are determined in a disk. Stress relief is obtained by cutting. Special attention is given to the sequence of cutting which has to start in points where stresses are low in order to avoid plastic deformation by local stress raises. Results are presented, obtained on two disks in which residual stresses were obtained by spinning. Very good agreement is found with analytical computations. W. Soete, Belgium

1540. Watanabe, H., Some remarks on the measurement of residual stress by Gunnert's method, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 107–110.

Accuracy of Gunnert's method for measuring residual stresses is discussed. Effects of the manner of supporting the tensometer, depth of trepanning groove in thin plates, and the influence of gage holes in thin plates are considered. Theoretical considerations are presented to enable rough corrections for the foregoing effects. Some experimental results are included.

M. C. Steele, USA

1541. Zakharov, V. P., An accelerometer using wire strain gages for measuring stresses in machines (in Russian), Stress and strain measurements in machinery parts, Moscow, Mashgiz, 1955, 101–130; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7241.

The mechanical characteristics of different accelerometers incorporating wire strain gages for recording the accelerations are discussed.

It has been possible by the use of such wire strain gages to construct an accelerometer of low weight (85 g), sufficient sensitivity (16mm/1g), and high natural frequency (~ 1000 c/s).

M. F. Zhukov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1542. Winter, K. G., and Petherick, E. J., Note on strain gauge recording equipment for the R.A.E. intermittent supersonic wind tunnels, *AGARD Publications, Rep.* 64, 12 pp. + iv, Aug. 1956.

A description is given of a simple system for photographing, up to six times per sec, revolution counters driven from strain-gage balance indicators. A further proposed system using punched cards is also described.

Results show that, even with comparatively slow strain-gage balance indicators, satisfactory recording of the loads on a model over a wide incidence range can be obtained in a run of 20-sec duration. From authors' summary

1543. Akao, S., Vibrating-wire strain gauge for long term tests and its application to the analysis of composite beam bridge, *Technol. Rep. Osaka Univ.* **6**, 95–102, Mar. 1956.

Modelled after the B. R. S. gage, a simple, durable and expendable measuring gage was made for trial, and was used to measure strains of a composite beam bridge. Author also made the reference gage with a simple amplifier unit.

The stress records of the Sogaya Bridge during construction are described. The strain measurements of the bridge were continued over half a year and the effects of shrinkage and creep were found to be quite large.

Although the gage is troublesome in fitting, it is reliable enough for practical use. In the future, the vibrating-wire gage will also be used widely together with other gages in Japan.

From author's summary

1544. Ritland, H. N., Stress measurement in cylindrical vessels, *J. Amer. ceram. Soc.* **40**, 5, 153–158, May 1957.

Transmission polariscope patterns produced by tempering hollow cylindrical glassware immersed in a fluid of the same refractive index are computed and compared with experiment. Unequal interior and exterior coding is said to add a linear distribution of bending stress to the proper parabolic distribution of compression at the surface and tension in the interior. Birefringence is taken as proportional to this stress. Technique of simple inspection and comparison seems excellent for quality control, and precise calculations also are possible. Author is unaware of the general photoelastic procedure of Drucker and Woodward [*J. appl. Phys.* **25**, Apr. 1954] which would enable him to check his assumption as to the distribution of birefringence through the thickness and also the work of Read [AMR **4**, Rev. 602] on glass envelopes.

D. C. Drucker, USA

1545. Chistyakov, A. M., and Karapetyan, R. A., An assembly for the measurement of axial force in model hydroturbines of the reactive type (in Russian), *Izv. Vses. n.-i. in-ta gidrotekhn.* **52**, 223–230, 1954; *Ref. Zh. Mekh.* 1956, Rev. 6270.

The measurement of the axial force is based on the recording with the aid of strain gages on three radially disposed cantilever arms, on to which is transferred the axial force of a model hydroturbine from its shaft. The registration of the readings of the deformation indicators is done with the aid of a needle-galvanometer with a mirror scale, built into the diagonal of the equal branch resistance bridge, fed by direct current.

Authors give a description of the construction of the apparatus, the results of the trials and calibration of the apparatus, which is divisible into its static and dynamic parts.

N. A. Gretsov, USSR
Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

1546. Campbell, W. R., and Suit, R. F., Jr., A transistorized AM-FM radio-link torque telemeter for large rotating shafts, *Proc. Soc. exp. Stress Anal.* **14,** 2, 55–66, 1957.

Rods, Beams, Cables, Machine Elements

(See Revs. 1459, 1469, 1501, 1502, 1503, 1510, 1524, 1537, 1543 1568, 1574, 1596, 1616, 1618, 1619)

Plates, Disks, Shells, Membranes

(See also Revs. 1505, 1506, 1507, 1527, 1569, 1570, 1571, 1572, 1575, 1581)

1547. Conway, H. D., Nonaxial bending of ring plates of varying thickness, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-92, 3 pp.

Differential equation for deflection w of a plate with circular symmetrical variable thickness loaded only at edges by normal forces or moments is suitable to solve by a statement of Fourier type. Rigidity law $D = D_0(r/a)^{-n}$ leads to a homogeneous equation whose characteristic is an easily solved quartic. The roots depend only on parameter m of cosine- or sine-members (e.g., cos $m\theta$), and n. Therefore each m involves finding four constants separately.

Numerical example deals with the case $n = 1$, the plate rigidly clamped at the inner boundary, the outer free but loaded only by single normal concentrated force P; radius ratio a/b is assumed to be 4. Development with the first 5 members and maximum deflection at the load are given, and greatest stress is compared with the results in the case $n = 0$, first published by H. Reissner.

W. Mudrak, Austria

1548. Bassali, W. A., and Dawoud, R. H., Bending of an elastically restrained circular plate under normal loading over a sector, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-8, 10 pp.

Continuing their studies on the deflection of circular plates [AMR **9,** Rev. 3557; **10,** Revs. 2845, 3238], authors use complex variable methods to treat the case of an elastically restrained plate loaded over a sector. Numerical results are obtained for a value of 1/3 of the Poisson ratio. If α is the semivertical angle of the sector, the central deflection is found to be α/π of the value for a completely loaded plate.

B. R. Seth, India

1549. Saleme, E. M., Stress distribution around a circular inclusion in a semi-infinite elastic plate, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-18, 7 pp.

Jeffery's solution in bipolar coordinates for the biharmonic equation is used to obtain an exact solution for the stress distribution in a semi-infinite plate with a circular inclusion. The condition at infinity is satisfied by taking a uniform tension parallel to the edge of the plate. Known limiting cases for a circular hole and that of a circular inclusion in a plate are deduced.

Numerical results are obtained for the value 1/3 of the Poisson ratio. It is found that the normal stress along the axis of symmetry is small.

B. R. Seth, India

1550. Bassali, W. A., and Dawoud, R. H., Green's functions for thin isotropic plates containing holes, *Proc. Camb. phil. Soc.* **53,** 3, 755–763, July 1957.

This paper is concerned with the small transverse displacement of an infinite thin plane isotropic plate due to the application of a transverse force applied at an arbitrary point of the plate. The plate has its outer edge free, and is clamped along and bounded internally by a closed curve that can be mapped onto the unit circle by means of a polynomial. Three polynomials are considered and in each of these cases the deflection is obtained in finite terms. Circular and elliptic holes as well as curvilinear polygonal holes are included as special cases.

From authors' summary by B. A. Boley, USA

1551. Bassali, W. A., The transverse flexure of thin elastic plates supported at several points, *Proc. Camb. phil. Soc.* **53,** 3, 728–743, July 1957.

Exact solutions in closed form are obtained for the problem of a thin circular plate supported at several interior or boundary points and normally loaded over the area of an eccentric circle, the load being symmetrical with respect to the center of the circle and the boundary of the plate being free. Explicit formulas for the deflection, the bending and twisting moments, and shearing stresses are given at any point of the plate. As limiting cases plates in the form of the infinite plane and half plane are also considered. Muskhelishvili complex-variable method is used for the solution.

From author's summary by B. A. Boley, USA

1552. Bassali, W. A., The transverse flexure of thin perforated elastic plates supported at several points, *Proc. Camb. phil. Soc.* **53,** 3, 744–754, July 1957.

Following the method of the preceding review, exact solutions in finite terms are obtained for the problem of an infinitely large plate with outer edge free and an inner free circular boundary, the plate being supported at any number of interior or boundary points and normally loaded over a circle. The load considered is symmetrical with respect to the center of the circle.

From author's summary by B. A. Boley, USA

1553. Sen Gupta, A. M., Stress in certain thin elastic plates rotating about normal axes (in English), *ZAMM* **37,** 1/2, 27–34, Jan./Feb. 1957.

A method is developed for evaluating the stress distribution within a rotating plate having curvilinear boundaries. It requires the deduction of a general form of the stress expressions from which one can obtain the unknown potential function. The method is illustrated by presenting a general solution to the problem of a rotating plate having a regular curvilinear polygonal boundary. The solution to a rotating plate with the shape of a dumbbell was also presented.

B. W. Shaffer, USA

1554. Nowacki, W., The stresses in a thin plate due to a nucleus of thermoelastic strain (in Polish), *Arch. Mech. stos.* **9,** 1, 89–106, 1957.

An isotropic disk with free boundaries is kept at zero temperature. Only an infinitely small element of its surface has temperature $T \neq 0$. On the basis of the analogy between the differential equation for the thermoelastic potential and the differential equation of the deflection surface of a membrane, loaded by a concentrated force, the state of stress is determined in the form of Green's function. Some of the boundary conditions are thus satisfied ($\sigma_n = 0$, $r \neq 0$). In order to satisfy the remaining conditions, another state of stress obtained by means of Airy's function is added. In the manner described, Green's functions for an infinite strip, a semiinfinite strip, and a semiinfinite plane are determined.

Z. Kączkowski, Poland

1555. Koppe, E., Method of nonlinear elasticity theory with application of a thin plate of finite bending (in German), *ZAMM* **36,** 11/12, 455–462, Nov./Dec. 1956.

A form of basic equations of the geometrically nonlinear theory of elasticity is used for application to thin plates with finite deflections. The differences between *Christoffel* symbols in two

different metrics (the deformed and the not-deformed body) give the conditions of compatibility.

H. Neuber, Germany

1556. Bassali, W. A., Transverse bending of a thin circular plate loaded normally over an eccentric circle, *Proc. Camb. phil. Soc.* **52,** 4, 742–749, Oct. 1956.

Complex variable method is used to obtain the transverse deflection in an eccentrically loaded thin circular plate subject to a general set of boundary conditions which include clamped and hinged edges. The area is divided into loaded and unloaded regions and the continuity conditions are satisfied on the common boundary. For clamped edges the solution is obtained in a closed form. No numerical results are given.

B. R. Seth, India

1557. Olszak, W., Murzewski, J., and Golecki, J., A nonhomogeneous elastic-plastic semi-infinite plate loaded by a concentrated force (in English), *Arch. Mech. stos.* **9,** 2, 197–214, 1956.

Paper is devoted to the determination of the state of stress and strain in an elastic-plastic semi-infinite plate loaded by a concentrated force acting normally to the edge of the plate.

It is supposed that the material of the plate is isotropic and nonhomogeneous, and its characteristics in the (s_i, c_i) system—s_i and c_i are intensities of stress and strain deviator, respectively—represent two intersecting straight lines; one of them defining the behavior of the material in the elastic region, the other, in the plastic region.

The nonhomogeneity in the elastic region is characterized by the Kirchhoff modulus G, which is assumed in the form $G(x) = G_{0g}(x)$, where x is the distance from the edge of the half-plane.

The nonhomogeneity in the plastic region is characterized by the yield point $K(x) = K_0 g(x)$ and by the modulus of strain-hardening $H(x) = H_0 g(x)$. The plastic and elastic nonhomogeneities of the material are, therefore, conjugate by means of $g(x)$.

The problem is solved for plane state of strain, in particular when the function $g(x) = x$ or $g(x) = x/(a + x)$.

The type of nonhomogeneity corresponding to the radial distribution of principal stress is determined, as well as the boundary between the elastic and plastic region and the displacement of the point of attachment of the force. For this purpose the logarithmic measure of elongation is used and incompressibility assumed.

A generalization of the problem to the case of an elastic-plastic wedge loaded by a concentrated force at the vertex is also given.

W. Urbanowski, Poland

1558. Kaczkowski, Z., Orthotropic rectangular plates with arbitrary boundary conditions (in Polish) *Arch. Mech. stos.* **8,** 2, 179–196, 1956.

A general method for determining the deflection of rectangular orthotropic plates, loaded in the plane of the plate and normally to its surface, is presented using double trigonometric series.

The influence of an elastic foundation is also taken into consideration. The boundary conditions are arbitrary (free or clamped edges, or simply supported along the contour or at the corners). Application of the method to the determination of the frequency of free vibration of rectangular plates with mixed boundary conditions is described.

Two numerical examples confirm the practical applicability of the method. However, neither the convergence of the trigonometric series used nor the conditions to be satisfied by the coefficients of the trigonometric series representing the general solution, in order to satisfy the differential equation of the problem, are considered.

J. Mossakowski, Poland

1559. McKenzie, K. I., and Rothman, M., Note on the bending of a circular plate under continuous non-normal loading, *J. roy. Aero. Soc.* **59,** 537, 632–635, Sept. 1955.

1560. Vartak, G. V., Cantilever moments in plates fixed along one of the long edges and subject to concentrated loads at a point on the other long free edge, *J. Instn. Engrs., India* **37,** 3, part 1, 203–212, Nov. 1956.

1561. Pivovarov, A. M., The determination of the shearing force in the bending of freely supported plates with singly and doubly linked regions (in Russian), *Trudī Mosk. energ. in-ta* **17,** 102–111, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7715.

The investigation is based on the results of M. G. Slobodyansky [*Prikl. Mat. Mekh.* **15,** no. 2, 1951], and in its first part, dealing with singly linked plates, is identical with the author's preceding paper [*Ref. Zh. Mekh.* 1954, Rev. 1698]. The transverse force on the periphery is determined by the equation

$$Q = \frac{\partial M}{\partial \nu} = \frac{1}{\pi} \iint_C \frac{\cos\theta_0}{r_0} p(\xi, \eta)\, d\xi\, d\eta - \frac{1}{n+1} \iint_C \psi(\xi, \eta) p(\xi, \eta) d\xi\, d\eta$$

Simultaneously, $\nabla^2 \psi = 0$, and on the periphery

$$\psi(\xi, \eta) = \frac{\cos\theta_0}{r_0} + \frac{\cos\theta_1}{r_1} + \ldots + \frac{\cos\theta_n}{r_n}$$

and $n + 1$ = number of points equidistant from the corresponding angles of the periphery, $\theta_0, \theta_1, \ldots$ = angles formed by the radii drawn from any point in the region C to the aforesaid points, with the internal normals to the periphery in these points.

The equation $\nabla^2 \psi = 0$ is solved by the grid method. For the continuous square or rectangular plate, the transverse force at individual points on the periphery is determined, and it is demonstrated that the result is obtained with a high degree of accuracy, even with a grid of relatively low density. The case is also examined of a square plate with a square opening, freely supported on the external and internal peripheries, as well as the analogous rectangular plate.

P. M. Varvak

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1562. Grashko, G. S., The bending of a thin, isotropic slab weakened by a semicircular cutout (in Ukrainian), *Prikl. Mekh.* **1,** 2, 177–181, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7690.

Author analyzes the stress distribution at semicircular cutouts in a thin isotropic slab [cf. G. N. Savin, "Stress concentrations at cutouts", Gostekhizdat, 1951]. Unilateral bending, pure bending, and torsion of the slab are the particular cases examined. For these cases, the values of the bending moment along the contour of the cutout have been calculated, and the corresponding curves plotted.

A.Ya. Gorgidze

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1563. Grigolyuk, E. I., The loss of stability in the extensive bending deflection of a laminated, conical closed shell under the action of a uniform pressure normal to the surface (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **22,** 111–119, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7698.

The large bending deflections are investigated of a flat conical bilaminar panel acted upon by a uniform transverse load. The points of the contour are assumed to be fixed in space. The fundamental equations of the axially symmetrical distortion of the panel, deduced in author's previous work [*Inzhener Sbornik* **17,** 1953], are the same as for a bilaminar, round plate with initial bending deflection, of the initial angle between the normal to the meridional line, and the central axis is assumed to be constant; thus the singularities in the distortion of the shell at the apex of the cone are not considered. The Poisson ratios μ of the two lamina are assumed to be equal.

The problem is solved by the Bubnov-Galerkin method, the angle of rotation of the normal to the original surface being approxi-

mated by the expression: $\theta = a(p^3 - kp)$; where ρ = the nondimensional, current radius, while the coefficient k has a value in the hinge-supported case of $k = (3 + \mu)/(1 + \mu)$; in the case of edge constraint $k = 1$.

The parameters of the shell by which the phenomenon of edge slip becomes possible are determined. Tables and curves are given, for the upper and lower critical loads and the corresponding bending deflections, for varying ratios of H: δ (H = height of shell, δ thickness), and varying conditions of support. These data are compared with the results of solution of the linear asymmetrical case; it being assumed in the latter that collapse is accomanied by the formation of a single half-wave along the meridian, and n half-waves along the arc.

A. S. Vol'mir

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1564. Burmistrov, E. F., The calculation of flat orthotropic shells with allowance for the ultimate deformation (in Russian), *Inzbener. Sbornik, Akad. Nauk SSSR* **22,** 83-97, 1955; *Ref. Zh. Mekb.* no. 11, 1956, Rev. 7697.

The ultimate strains in flat orthotropic shells of rectangular planform are investigated for the case of an external load uniformly distributed over the surface of the shell.

Two particular cases are examined: the bending of a flat shell the edges of which do not diverge under deformation; and the deformation of a flat shell, the edges of which do not remain rectilinear under a deformation load.

In the first case, if the deflection and curvature function is represented by Fourier expansions, the condition of compatibility of the distortions in an orthotropic shell enables the author to determine the stress function satisfying all boundary conditions and a symmetrical distribution of the stresses acting in the median surface of the shell. The problem is solved in first approximation. Integrating the equilibrium equation by the Buknov-Galerkin method, author establishes a cube-law relationship between the relative bending deflection at the center of the shell and the load parameter. An example is worked of a flat orthotropic shell of rectangular planform, with double curvature, the curvatures being approximated by the parameters of the shell. Tables are given for the values of these parameters, as well as curves of the ratio of relative bending deflector to the load parameter.

In the second case, the equation of the compatibility condition for the distortions and the equilibrium equation of the orthotropic shell are integrated by the Bubnov-Galerkin method. The functions approximating the bending deflections, and the stress function, are represented by the fundamental beam functions. The problem is in first approximation.

R. G. Surkin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1565. Alexandrovsky, S. V., On the stability of a cylindrical shell under considerable bending deflection (in Russian), Calculation of three-dimensional frameworks, no. 3, 1955, 453-492. Moscow, State Publ. Off. for Civ. Eng. & Architect; *Ref. Zh. Mekb.*, 1956, Rev. 4634.

Fundamental relationships are derived for the nonlinear theory of thin orthotropic circular-cylindrical shells subjected to external axial forces and a load acting transversely. To take account of the formation of a small number of peripheral corrugations, author uses the following expression for the circumferential variation of the curvature

$$\kappa_y = -\left(\frac{\partial^2 w}{\partial y^2} + \frac{w}{R^2}\right) \qquad [1]$$

instead of

$$\kappa_y = -\frac{\partial^2 w}{\partial y^2} \qquad [2]$$

customarily used for shells of "average length" (w = bending deflection, R = radius of shell, y = circumferential coordinate).

The variational equation of the problem is derived by the principle of possible displacements. The work of the transverse load in the possible displacement is determined with allowance for the influence of the annular forces, as is done in the linear theory of the stability of rings and shell [cf. P. F. Papkovich, "The structural mechanics of the ship," pt. 1, Vol. 2, "Morskoy Transport," 1947, p. 224]. As a result, author arrives at a differential equation of equilibrium, containing a term depending on the intensity of the transverse load q

$$q\left[1 - R\left(\frac{\partial^2 w}{\partial y^2} + \frac{w}{R^2}\right)\right] \qquad [3]$$

The equations of the Ritz method and of Bubnov-Galerkin are introduced for investigation of the hypercritical deformation of the shell. The approximate expression for the bending deflection is given in the form

$$w = C_1 \sin\frac{s\pi x}{l}\sin\frac{ny}{R} + C_2 \sin\frac{s\pi x}{l}\sin^2\frac{ny}{R} \qquad [4]$$

s and $2n$ are the number of half waves (corrugations) in the length l and along the circumference. A method is presented for determining the lower critical load value. Concrete examples are given of the calculation of a smooth shell and a shell reinforced by ribs, of the usual type, for an absorption tower under the action of axial compression and external pressure.

The equations obtained by author furnish, in particular, the von Mises expression for the upper critical pressure under external transverse loading or multilateral pressure (compression), and thus refer to the case of a "long" envelope. For nonlinear problems, however, these equations may lead to erroneous results. The equation of equilibrium of an element of the shell contains, in addition to Eq. (e), the term

$$t_y \sigma_y\left(\frac{1}{R}\frac{\partial^2 w}{\partial y^2}\right) \qquad [5]$$

in which t_y = referred width, σ_y = circumferential force. The value σ_y in turn includes a term depending on the transverse loading ($-qR/t_y$), consequently the equation twice contains the term ($-qR\partial^2 w/\partial y^2$).

Applying for the curvature κ_y the more accurate expression [1], author applies the term of order $1 : n^2$ by comparison with Eq. [2]. It is the necessary, however, to revise the remaining expressions for the deformation of the median surface and curvature [cf. V. V. Novozhilov, "Principles of the nonlinear theory of elasticity," Gostekhizdat, 1948, 178-185].

A. S. Vol'mir, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

1566. Chernika, V. S., The stress condition of a compensating pipe bend working under flexural load (in Russian), *Inzbener. Sbornik, Akad. Nauk SSSR* **22,** 133-149, 1955; *Ref. Zh. Mekb.* no. 11, 1956, Rev. 7702.

The distortion of a toroid shell is examined, loaded on the edge $\theta = \theta_0$ (where θ is the angle between the normal to the medium plane and the axis of the shell) by a bending moment M.

As in the case of the symmetrical deformation of toroid shells [cf. V. V. Novozhilov, "Theory of thin shells", Sudpromgiz, 1951, 278-289], the problem is reduced to the solution of a second-order linear differential equation for an unknown complex function, which is integrated in Bessel functions.

The results of the calculation of a circular compensating pipe bend are presented; the calculated stresses are compared with the experimental values.

M. S. Kornishin
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Buckling Problems

(See also Rev. 1524)

1567. Wagner, H., Stability calculation of columns of stepwise variable cross section with the help of Laplace transformation and matrix calculation (in German), *ZVDI* **99,** 25, 1251–1256, Sept. 1957.

After a short description of the fundamental properties of Laplace transformation, practical application of this method to the problem of buckling of columns with stepwise variable cross section is introduced. Simplicity of this method, especially when using matrix notation, is shown in comparison with that of solving differential equations in normal way. Numerical example concludes this informative paper. V. Kopriva, Czechoslovakia

1568. Bartlett, R. J., Bending and axial stresses in rectangular columns, *Concr. constr. Engng.* **52,** 4, 129–134, Apr. 1957.

1569. Yamaki, N., Buckling of a thin annular plate under uniform compression, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-11, 7 pp.

The problem of the elastic stability of a thin elastic annular circular plate subject to radial compressive forces applied uniformly around the boundary and acting in the plane of the middle surface of the plate is considered. Using linear small deflection theory the equilibrium equations are integrated in terms of Bessel functions, and the constants of integration corresponding to twelve different combinations of boundary conditions are determined. For each case the lowest critical load is calculated using the ratio of the inner and outer radii of the plate as a parameter. In contrast to previous investigations by Olsson [*Ing.-Arch.* **8,** 1937] and Schubert [AMR **4,** Rev. 457] the present paper does not make any assumption regarding symmetrical buckling, and consequently lower buckling loads are presented than have been found in previous studies in which symmetrical buckling was assumed. Convenient curves represent buckling stress coefficients as a function of the geometry of the plate. Discussions of the limiting cases of a solid circular plate as well as an infinite strip are also included. W. A. Nash, USA

1570. Gerard, G., and Becker, H., Handbook of structural stability. III. Buckling of curved plates and shells, *NACA TN* 3783, 84 pp. + 7 tables + 51 figs., Aug. 1957.

This part of handbook contains complete and thorough discussion and, in many cases, further evaluation of known data on title subject, for which, in reviewer's opinion, authors deserve high praise.

For cases in which effects of initial eccentricities do not lead to marked discrepancies between linear theory and test results (torsion, shear, external pressure on cylinders), latter are correlated in terms of linear theories for both elastic and inelastic ranges. For other cases (compression, bending, external pressure on spheres), unified semiempirical approach is attempted. Combined loadings are treated by means of interaction curves.

It should be noted that proposals made aim to represent average rather than conservative values.

Reviewer remarks that authors tacitly disregard results of compression and bending tests on small-size specimens of Ref. 8 (see, e.g., fig. 16), which are confirmed by recent tests [AMR **10,** Rev. 3980] and point rather convincingly to appreciable size effect on relative initial eccentricities and thus on buckling stress coefficients C and C_b (also see AMR **2,** Rev. 726); quality of manufacturing technique will also affect these coefficients.

F. J. Plantema, Holland

1571. Gerard, G., Handbook of structural stability. IV. Failure of plates and composite elements, *NACA TN* 3784, 50 pp. + 15 tables + 28 figs., Aug. 1957.

Postbuckling behavior under compressive loads and failure of flat and curved plates, as well as crippling strength of formed and extruded stiffeners, are reviewed in this fourth part. Effects of Alclad coatings and increased properties in corners of formed shapes on crippling strength are included.

Author has devoted considerable effort to present all data by means of simple formulas of same general form, containing some empirical constants derived from test results. For crippling strength of sections, surprisingly simple results are obtained, which appear to be in satisfactory agreement with test data.

Apart from having minor criticisms regarding clarity or correctness of a few statements, reviewer noted some serious printing errors, viz.: on p. 43 in 18th line "equation (5)" should read "equation (6)"; on p. 51, 3rd line "reference 8" should read "reference 9"; in lower half of fig. 6 ordinate should probably be $0.1\ \bar{\sigma}_f/\sigma_{cr}$ instead of $\bar{\sigma}_f/\sigma_{cr}$.

F. J. Plantema, Holland

1572. Gerard, G., Handbook of structural stability. V. Compressive strength of flat stiffened panels, *NACA TN* 3785, 46 pp. + 9 tables + 25 figs., Aug. 1957.

Fifth part of handbook deals with various phenomena which may determine compressive strength of stiffened panels.

Simple general formula is proposed for crippling strength, empirical constants being derived from tests on riveted panels. In further sections, effects of interrivet buckling or forced crippling, and column strength of stiffened panels are discussed. Optimum design is then dealt with, and some observations are made concerning strength of panels which form part of wing or tail structure of airplane. F. J. Plantema, Holland

1573. Becker, H., Buckling of composite elements, *NACA TN* 3782, Pt. II, 19 pp. + 54 figs., July 1957.

This second part [for first part see AMR **11,** Rev. 822] deals with local buckling of stiffeners, and buckling of stiffened flat or curved plates under longitudinal compression or shear, when stiffeners do not buckle locally. Results of survey are given in series of charts and tables. Effects of plasticity are discussed for a few special cases.

In reviewer's opinion more attention should have been given to ready applicability of results. For instance, significance of a and b in fig. 10 would have been immediately clear by adding sketches as in other figures (footnote on p. 3 must be remembered); it is neither clear from text nor from figure which increase is given in fig. 15; k_s in fig. 14 should read k_c, etc. Such minor defects are a pity in this valuable survey.

F. J. Plantema, Holland

1574. Bartlett, R. J., Bending and axial stresses in hollow circular columns, *Concr. Const. Engng.* **51,** 11, 537–543, Nov. 1956.

1575. Alfutov, N. A., Shell stability calculations using the potential energy method (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **22,** 120–132, 1955.

Joints and Joining Methods

(See Revs. 1610, 1617)

Structures

(See also Revs. 1508, 1535, 1536, 1543, 1589, 1598, 1603, 1604, 1607, 1616, 1628, 1630, 1632, 1636, 1657, 1737, 1821, 1823)

1576. Heyman, J., Plastic design of pitched-roof portal frames, *Proc. Inst. civ. Engrs.* **8,** 119–140, Oct. 1957.

Part 1 of paper briefly reviews plastic theory of single-bay portal frame, including approximate effect of deflections, and illustrates theory by design calculations for a series of gabled frames with spans from 25 to 100 ft. Part 2 is concerned primarily with multi-bay gabled frames and mentions a simple empirical rule, due to Merchant, for calculating the approximate collapse load in terms of the elastic instability load and the plastic collapse load. Part 3 reports tests on small models of one- and two-bay frames having columns spaced at 6 in. Allowing for an 8% experimental error deduced by author, results of one-bay tests appear to correlate well with theory. Measured two-bay collapse loads generally were from 16 to 34% below calculated values, the larger discrepancies occurring when middle column was pin-ended.

Author mentions instability as likely cause of discrepancies. Reviewer suggests that buckling mode leading to a lower critical load than that assumed by author might not have been considered.

J. E. Goldberg, USA

1577. Bonnickson, L., Multicombination pole-type construction, *Oregon State Coll. Agric. Exp. Sta. Bull.* 557, 32 pp., Oct. 1957.

Complete design details are presented for pole-type structures, with poles spaced lengthwise 14 ft and crosswise 24 ft.

Ring connectors, bolts, and nails are used in combination for fastening the lumber, despite the fact that these three types of fasteners do not necessarily act simultaneously in transmitting loads. The use of annularly threaded nails is recommended for conditions where helically threaded nails are more effective.

E. G. Stern, USA

1578. Valentin, W., Calculation of a wall-type girder according to the composite method (in German), *Beton u. Stahlbeton,* **52,** 8, 176–182, Aug. 1957.

For the sake of calculating a wall-type girder, the wall is cut in parallel strips, which are computed by the simple-beam theory. The beams must pass without open space and without a spring of the stresses in the intersections. These conditions require loads for the beams and shearing stresses in the intersections. The method is illustrated by some examples. L. Foppl, Germany

1579. Gartner, R., Design of statically-indeterminate structures by the "plastic-hinge" method, *Concr. constr. Engng.* **52,** 5, 161–174, May 1957.

1580. Krausche, K., Moment distribution combined with solution by equations (in German), *Stahlbau* **26,** 1, 22–24, Jan. 1957.

When a continuous bent or rigid frame is analyzed for a number of different loadings it may be advantageous to find the effects of individual single loadings which may then be combined variously to form the actual loadings. In present method, an external moment is applied to a single joint, is distributed to the members connecting to it, and is carried over to their far ends. The joints loaded by their carry-overs are balanced and the effects carried over once more to the far ends of all members participating. Unbalanced joint moments are then totaled, giving a large value to the joints originally loaded, zero on all joints contiguous to it, small moments on all joints next in distance, and zero on all remaining joints. By repeating this process, applying external moments to the various joints of the structures in turn, one obtains very quickly a series of basic loadings that can be combined to represent the actual loadings.

Author also obtains influence lines for bending moment. Sidesway is treated. M. P. White, USA

1581. Klockner, G. and Radulescu, C., Contribution toward solving the continuity problems occurring in floor slabs and beams of precast reinforced concrete (in Rumanian), *Indust. constr. Mater. constr.* **8,** 9, 496–501, 1957.

Beams are precast in V-shape with transverse concrete stiffenings 4-ft o.c., and put in place with spacings from 30 to 40 in. Two types of interconnecting slabs are described. Type U_1 are precast slabs, 1 in. thick, with transverse joints, to be filled with concrete for continuity. Continuity with beams is provided by concrete poured in spaces of V-shaped beams and additional reinforcement. Type U_2 is poured in place on arched steel sheets, and the thickness of the slab increases from 1¼ to 1¾ in. The great economy of this structural type is discussed. J. J. Polivka, USA

1582. Brouwer, G., and Van Der Meer, S., A network analog of a statically loaded two-dimensional frame, *Proc. Soc. exp. Stress Anal.* **15,** 1, 35–42, 1957.

Bending bars can be dealt with by the method of concentrated forces and elasticity. The beam is replaced by a fictive model, consisting of an assembly of rigid bars, connected by elastic joints, so that the elasticity of the joints equals the elasticity of the adjoining halves of the bars in the original beam. A continuous load is divided into a number of concentrated loads acting in the middle of the rigid bars. The set of equations governing the behavior of the fictive model may be represented by an electric analogy consisting of resistor networks and amplifiers.

The possibilities of the method are demonstrated by a number of examples. Forces, moments and deformations correspond with currents and potentials of the electric model. The design of a general-purpose analog computer for these problems is discussed.

R. G. Boiten, Holland

1583. Wei, L., Analysis of rigid frames with curved or gabled beams by the method of propagating unbalanced moments and lateral forces (in Chinese), *Chinese J. civ. Engng.* **3,** 4, 439–461, Nov. 1956.

A single-cycle moment distribution method is shown for rigid frames with curved or gabled beams. The unbalanced moments and lateral forces at the joints are distributed and transmitted to neighboring joints by modified stiffness factors and carry-over factors. These modified factors for the joint are calculated from the consideration of the elastic properties of the connecting structure. T. H. Lin, USA

1584. Design of flexible pavements, *Nat. Res. Counc. Highway Res. Bd. Res. Rep.* 16-B, 12 papers, Jan. 1954.

1585. Elyava, G. A., A particular case of statistical truss analysis for deformation by graphical means (in Russian), *Nauch. tr. stud. Gruz. s.-kh. in-ta* **5,** 239–244, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7876.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1586. Ginzburg, M. B., Determining the intensity of counter-pressure in gravitation dams erected on a rocky foundation (in Russian), *Izv. Vses. n.-i. in-ta gidrotekhn.* **53,** 98–117, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5326.

The problem of calculating the counter-pressure in plant erected on rocky foundations is examined. A description is given of the design of piezometers of closed and open type.

Measures are examined which reduce the anti-pressure by applying cementation curtains, draining the foundations, and certain design measures for solving this problem.

The data from natural observations on a number of Soviet dams erected on a rocky foundation are given, as well as data from literature relating to a number of dams in the U.S.A.

It is stressed that in the design of gravitational dams it is essential to provide several gates with a necessary number of piezometric generators for pressure measurement.

P. F. Fil'chakov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1587. Williams, D., A constructional method for minimising the hazard of catastrophic failure in a pressure-cabin, *Aero. Res. Counc. Lond, curr. Pap.* 286, 13 pp., 1956.

A method is put forward for substantially reducing the chances of a local failure in the shell of a pressure cabin from developing into catastrophic failure of the cabin. The increased safety is achieved without weight penalty, and consists essentially in using closely-spaced (10 in. or thereabouts) transverse flat bands, the material for which is obtained by reducing the sheet thickness normally available for the shell walls.

From author's summary

1588. Fridman, Ya. B., and Sobolev, N. D., On methods of estimating and increasing the strength of bodies made of anisotropic materials (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **106,** 4, p. 611, Feb. 1956.

Failure, Mechanics of Solid State

(See also Revs. 1590, 1606, 1621, 1627)

1589. Whaley, R. E., Fatigue investigation of full-scale transport-airplane wings; variable-amplitude tests with a gust-loads spectrum, *NACA TN* 4132, 43 pp., Nov. 1957.

Variable amplitude loadings were applied to three full-scale complete wings from a transport airplane until fatigue occurred. Load spectrum duplicated gust load frequency observed in flight [*NACA WR* L-121, 1944]. Comparison with constant amplitude tests on same wings [*NACA TN* 3190 and 3847] showed nature and number of cracks corresponded more nearly to high constant-amplitude results. Linear cumulative damage theory greatly underestimated final life; first crack was reasonably well predicted, but average occurred more than 3.5 times later and cracks propagating to failure initiated about 3 times later. E. T. Welmers, USA

1590. Weibull, W., Scatter of fatigue life and fatigue strength in aircraft structural materials and parts, *Flygtekn. Försöksanst. Medd.* no. 73, 25 pp., 1957.

Article suggests that the *scatter* of *strength* shows advantages over the *scatter* of *life* when the fatigue properties are subjected to axial loading which is described by a single *S-N* diagram, such as the median one and the probable deviation from this curve. The distribution of fatigue strength is largely independent of log *N*. Author has studied 11 materials with and without stress raisers, such as Cr-Mo steel, 24S-T Alclad at room temperature and 200C, 75S-T, copper in torsion at constant strain amplitude, and carbon steel as a threaded bolt. The lowest number of specimens tested was 30 for 24S-T Alclad at 200C, while the highest was 1088 specimens for 24S-T Alclad at room temperature.

Author states that the fatigue strength is a stochastic variable defined by a distribution when the sample is taken from a homogeneous population, but there are three irregularities. A few specimens fail after a very small number of cycles. Some specimens may endure stress cycles much larger than those estimated by the distribution function. The median of the different stress levels is very well fitted by an *S-N* curve with the exception of a single stress level which may be attributed to a peculiarity of the testing machine.

Further work is needed to determine the applicability to constant strain and constant load fatigue at various temperatures and to thermal fatigue testing. H. Majors, Jr., USA

1591. Nishihara, T., and Yamada, T., Fatigue life of metals under varying repeated stresses, Proc. sixth Japan nat. Congr. appl. Mech. Univ. of Kyoto, Japan, Oct. 1956, 61-64.

Based on several assumptions, authors derive formulas for: (1) S_a-N curves at different mean stresses, (2) S_m-N curves at different stress amplitudes, and (3) fatigue life under constant stress amplitude and sinusoidally varying mean stress. Plane bending fatigue tests on steel specimens, notched by a circumferential groove, are in agreement with formulas. Reviewer believes that a more elaborate explanation of the mathematical treatment and its physical significance would facilitate a better appreciation of this interesting paper. J. Schijve, Holland

1592. Vyalov, S. S., The creep and fatigue resistance of frozen soils (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **104,** 6, 850-850, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7821.

The resistance (mechanical strength) of frozen soils is conditioned by primary (essentially molecular) and secondary (originating at the formation of the stratum) cohesive forces. The specific influence of ice in cementing the soil particles is underlined. Two types of creep deformation can be distinguished: fading creep (structural deformations) accompanied by an increase in resistance, and non-fading creep (plastic flow). Experiments show that the relationship between the magnitude of the breakdown load and the time through which it acts can be represented by a curve, the ordinates whereof vary from the value of conditionally instantaneous strength to the limit of fatigue endurance. Stresses below the endurance limit do not cause breakdown, even when acting over prolonged periods.

It is observed that the rheological processes developing in frozen soils do not follow the characteristic laws for elastically tenacious substances. They are better described by the integral equation of the theory of hereditary creep developed by Yu. N. Rabotnov [*Izv. Akad. Nauk Otd. tekh. Nauk* no. 6, 1948] or an approximate equation considering the nonlinear character of the relationship between deformation and load (strain and stress) during any period of action of the loading, excepting an instantaneous load, as suggested by M. M. Rozovsky [*Zh. tekh. fiz.* **21,** no. 11, 1951].

N. Ya. Denisov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1593. Hess, R. W., Fralich, R. W., and Hubbard, H. H., Studies of structural failure due to acoustic loading, *NACA TN* 4050, 11 pp., July 1957.

Some discussion of the acoustic fatigue problem of aircraft structures is given along with data pertaining to the acoustic inputs from some power-plants in common use. Comparisons are given for results of some fatigue tests of flat panels and cantilever beams exposed to both random- and discrete-type inputs. In this regard it appears that both the stress level of the test and the type of model are significant; hence no generalization can be made at this time. With regard to increasing the fatigue life, it was noted that increased stiffening of a panel due to curvature and pressure differential is particularly beneficial.

From authors' summary

1594. Hardrath, H. F., and Whaley, R. E., Fatigue-crack propagation and residual static strength, *NACA TN* 4012, 7 pp. + 8 figs., May 1957.

1595. Garai, T., Influence of fatigue on the strength properties of torsionally loaded reinforcing steel, *Mélyépitéstudományi Szemle* **7,** 1/3, 72–75, Jan./Mar. 1957.

1596. Halgren, J. A., and Wulpi, D. J., Laboratory fatigue testing of gears, *SAE Trans.* **65,** 452–470, 1957.

1597. Lazan, B. J., Fatigue under resonant vibrations considering both material and slip damping, *Proc. Soc. exp. Stress Anal.* **15,** 1, 1–20, 1957.

Design criteria are studied for components under resonant vibration. Effect of internal damping and external slip damping are considered. Former depends on range and distribution of stress, latter on interface pressure and contact geometry. Examples show that a material of low fatigue limit and high damping may, under certain conditions, be superior to one with a high fatigue limit and low damping. Examples of slip damping are also considered. R. N. Arnold, Scotland

1598. Pope, J. A., Foster, B. K., and Bloomer, N. T., A survey of the problem of limited life design, *Civ. Engng., Lond.* **51,** 604, 1129–1131, Oct. 1956.

1599. Frisch, J., Comparison of semi-empirical solutions for crack propagation with experiments, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-12, 6 pp.

The crack-propagation characteristics of two aluminum alloys and several steels have been investigated in sheet materials under uniaxial tension. Empirical formulas based on ultimate strength and initial crack length were found to be a sufficiently effective method for establishing the relative merit of a material in its resistance to crack propagation. Comparison of experimental data with criteria obtained from the energy-release rate or stress-concentration theory shows that neither method yields reliable material constants. From author's summary

1600. Dance, J. H., and Clauss, F. J., Rupture strength of several nickel-base alloys in sheet form, *NACA TN* 3976, 24 pp., Apr. 1957.

An investigation was conducted to determine the 100-hr rupture strengths at 1200 and 1350 F of Inconel X, Inconel 700, Incoloy 901, Refractaloy 26, and R-235 sheet alloys in both the annealed and heat-treated conditions. The strongest alloys at 1200 F were Inconel 700 and Incoloy 901 in the heat-treated condition, with strengths of 77,500 and 76,500 psi, respectively. At 1350 F, the strongest alloys were heat-treated Inconel 700 and R-235 with respective 100-hr strengths of 57,500 and 53,500 psi. Incoloy 901 in the annealed condition was the most ductile, with an elongation in stress-rupture of 6 to 20%. In both the annealed and heat-treated conditions, the other alloys elongated only about 1 to 5%. Photomicrographs show that fractures occur predominantly in the grain boundaries. The strengths of these alloys are compared with published data for other sheet alloys and bar stock.

From authors' summary

1601. Peters, R. W., and Kuhn, P., Bursting strength of unstiffened pressure cylinders with slits, *NACA TN* 3993, 21 pp., Apr. 1957.

Internal-pressure tests were made on aluminum-alloy unstiffened cylinders with precut slits to study the effect of slit length and curvature on the hoop stress developed at the bursting pressure. The results are predicted with good accuracy by applying a curvature correction to the method presented in *NACA TN* 3816 for computing the strength of flat plates with cracks. In this investigation cylinders were pressurized with air and with oil. The results indicate that the pressurizing medium has a negligible effect on the bursting pressure.

From authors' summary

1602. Freeston, R. O., Roberts, J. D., and Thomas, A., Crankcase explosions: an investigation into some factors governing the selection of protective devices, *Inter. Shipbldg. Progr.* **4,** 29, 24–39, Jan. 1957.

Remedies which have been suggested for crankcase explosions include the use of warning devices to detect overheating in the crankcase, and the provision of relief vents to limit the explosion pressure to a safe value.

Data were obtained experimentally at the Thornton Research Centre for the conditions necessary for the ignition of mists of lubricating oil in air in order that the margin of safety offered by a detector of overheating might be more fully assessed.

The venting of explosions was also studied both on a rig scale and in the crankcase of a diesel engine of 1100 hp. The results indicated that it would not be practical to provide sufficient venting area on an engine of this size, to limit the maximum explosion pressures to a safe value for the more violent explosions which might occur. For venting to provide complete protection, it would seem necessary to take measures to prevent the flame from spreadthroughout the whole crankcase. From authors' summary

1603. Anderson, B. G., Rigid frame failures, *J. Amer. Concr. Inst.* **28,** 7, 625–636, Jan. 1957.

The fundamental behavior of concrete members in transferring shear load is not fully understood, and in some cases designs have resulted in costly failures. One such failure occurred when portions of some U. S. Air Force rigid-frame warehouses collapsed. General nature of distress is described; materials and construction procedure are analyzed briefly. A critical review of the design suggested some points subject to question. Some general comments are offered on shear design. From author's summary

1604. Brice, L. P., Tensile cracks in brittle bodies and in reinforced concrete (in French), *Ann. Inst. tech. Bât. Trav. publics* no. 109, 81–92, Jan. 1957.

Author studies the tensile cracks in brittle bodies and in reinforced concrete. He sets up formulas giving the mean spacing of the cracks and their width. With these formulas it is possible to calculate, in function of the characteristics of the section, the maximum stress in the reinforcing steel for a determined mean width of the cracks. From author's summary

1605. Elstner, R. C., and Hognestad, E., Laboratory investigation of rigid frame failure, *J. Amer. Concr. Inst.* **28,** 7, 637–668, Jan. 1957.

An experimental investigation into the causes of failure in a rigid frame warehouse is reported. The type of diagonal cracking that caused the failure was reproduced in the laboratory; revised frame designs for future construction were tested; and remedial measures were developed to strengthen existing frames by prestressed steel strapping applied externally.

Though further studies are needed to clarify completely the fundamental mechanism of failure, it is believed that the failure took place by a combination of diagonal tension due to dead load and axial tension due to shrinkage and temperature change. It is considered highly probable that the type of distress involved can be avoided by sufficient web reinforcement, sufficient extension of longitudinal reinforcement beyond the region of contraflexure, and effective expansion joints. From authors' summary

1606. Schaeffer, A. O., Work of the task group on brittle failure of steel forgings, *Trans. ASME* **78,** 7, 1623–1626, Oct. 1956.

1607. Lazard, A., Research on the cracking of concrete prisms reinforced with a round bar working under pure tension (in French), *Publ. int. Assn. Bridge struct. Engng.* **16,** 345–356, 1956.

In order to check the validity of M. Brice's theory concerning the spacing of cracks in reinforced concrete under tension, the

French National Railways undertook, from 1952 to 1954, a series of tests on concrete prisms reinforced with a round bar submitted to pure tension.

The results prove that, on the whole, this theory is fairly correct; however, the minimum spacing of the cracks is about half of that expected, whereas the maximum spacing is about 1.25 times larger. The magnitude of the mean spacing is given fairly by the formulas of M. Brice.

The tensile stress transmitted by the steel is fully distributed in the total section of concrete, at a certain distance only from the ends.

Only on very long prisms have the cracks gone fully through the concrete. From author's summary

1608. Probst, H. B., and McHenry, H. T., A study of the impact behavior of high-temperature materials, *NACA TN* 3894, 23 pp., Mar. 1957.

The impact properties of titanium-carbide-base cermets, some high-temperature alloys, and the intermetallic, NiAl, were obtained at room and elevated temperatures to 1750 F. The impact energies of cermets were found to increase with increased amounts of metallic binder. The composition of an alloy binder influenced the resistance to impact failure. As might be expected, this influence may be beneficial or detrimental, depending on the particular alloy. Less angular carbide particles resulted in an improved impact strength of cermets, which was only slightly affected by test temperature. The general trend was a decrease in impact strength with increased temperature.

Within the range of notch radii investigated, a cermet composition showed continuous decreasing impact resistance as the notch radius of the test bar was decreased. When cermets and alloys were compared on the basis of impact resistance, most cermets were less resistant to impact failure than brittle alloys.

Variables such as gripping force, gripping material, and repeated blows that affected the impact resistance measured by the drop test are discussed, and a modified specimen supporting arrangement to eliminate the first two variables is presented.

From authors' summary

1609. McDowell, D. W., Raudebaugh, R. J., and Somers, W. E., High-temperature corrosion of alloys exposed in the superheater of an oil-fired boiler, *Trans. ASME* **79,** 2, 319–328, Feb. 1957.

A series of heat-resistant alloy test racks containing some 30-odd test specimens was installed in the gas inlet of the second bank of the superheater in a Public Service Electric and Gas Company boiler. This boiler had been burning bunker C fuel oil for the three-year period before the test and used bunker C during the entire test period. Gas temperatures varied from 1560 F at full load to 1100 F at minimum load. The loading on the boiler during the investigation was considered typical of steam-boiler operation. Scale taken from the build-up on the test specimens analyzed as high as 36% vanadium pentoxide and 32% sulphuric anhydride. An analysis of the ash constituents present in the oil-fired boiler during the tests also showed high vanadium, sulphur, sodium, and calcium contents. All corrosion rates were measured by metallographic examination and were expressed as inches penetration for the duration of the test and extrapolated to inches per year (IPY). Corrosion results were obtained on both cast and wrought alloys as well as some alloys with various coatings. An extensive metallographic investigation was conducted on all alloys exposed to determine the type of attack each material underwent during the exposure period. Some alloys had a corrosion rate as much as ten times greater than others. From authors' summary

1610. Masubuchi, K., and Yada, T., Some problems of elastic dislocation and their application on residual welding stresses, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 23–26.

The problem of residual welding stresses is studied analytically by making use of the similarities between the theory of inherent stress and that of vorticity in hydrodynamics. Several examples of elastic dislocations are presented. Analysis is made of dislocations which result from the release of residual stress. Authors consider the ring-type, slit-type, and circular patch weld specimens.

No comparison with experimental data is presented. The paper suffers because of improper word usage and poor grammar.

J. E. Stallmeyer, USA

1611. Hardy, H. K., Metallurgical research and development for nuclear power, *J. Inst. Metals* **84,** 229–238, 1955–1956.

The expanding demand for electricity can be met only by power derived from nuclear energy. Descriptions of the Calder Hall type of thermal reactor and the Dounreay experimental fast reactor indicate the scale of effort involved. The type of fuel element selected depends on the operating conditions, the temperature, heat flux, and coolant, which are related to the specific power rating required from the uranium fuel.

A decision to build a power reactor imposes a time-table on the research and development work, in which a balance must be struck between the problems posed and the ability to provide satisfactory solutions by the correct date. The case of a hypothetical reactor is examined, in which five years is allowed from the decision to design to the production of power. The flow-sheets for the fuel and canning operations would be required at the end of the second year. Research and development start with a range of materials which is successively narrowed down, while the scale of the prototype production and testing is progressively increased. Longer-term investigations are aimed at reducing the cost of electricity by providing fuel elements of improved efficiency and longer life.

From author's summary

1612. Kryanin, I. E., Cavitation damage in the blading of high-power hydraulic turbines (in Russian), Energomashinostroyenie no. 3, 14–18, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7439.

The results are discussed of observations of cavitation breakdown in the blades of hydraulic turbines of high power, up to 40,000–65,000 Kw. per unit. The turbine blades were made of 30-L, high-carbon steel and 20X13NL and 25X14NL, high-chromium stainless steels, respectively. In some of the turbines, for the purposes of research, different steels were used in the blading. The running times after which the observations were made varied from 4000 to 64,588 hours. The investigations showed that the high-chromium stainless steel is more resistant to cavitation damage than the carbon steel, but nevertheless ultimately succumbs to progressive destruction depending on the total running time (time in service). The following forms of cavitation damage were encountered: (1) In the blade roots next to the casing wall about the middle or last third of the blade root profile; (2) on the lower blade surfaces next to the pitted blade roots; (3) on the lower blade surfaces behind the assembly plugs; and (4) on the lower blade surfaces next and parallel to the leading edge. A brief discussion of the causes of cavitation pitting is appended.

K. K. Shal'nev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1613. Glickman, L. A., and Rajchelson, E. M., A comparative evaluation of the methods of determining cavitation (erosion) resistance (in Russian), Hydraulic turbine construction, no. 1, Moscow-Leningrad, Mashgiz, 1955, 225–232; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7440.

A comparison is made between two methods of testing metals for resistance to cavitational erosion (cavitation pitting); the vibration testing of samples and the impact testing of a rotating sample. A series of ferrous and nonferrous metals were tested. In the

vibration tests with a magnetostrictive vibrator, a synthetic sea water (brine) was used; while in the jet impact test, ordinary tap water was the medium. The experimental results show qualitative agreement between the two methods. K. K. Shal'nev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1614. Eshelby, J. D., The determination of the elastic field of an ellipsoidal inclusion, and related problems, *Proc. roy. Soc. Lond.* (*A*) **241,** 1226, 376–396, Aug. 1957.

A region within an isotropic elastic solid is affected by a change which, without the surrounding material, would be some prescribed homogeneous deformation, for instance, thermal expansion. The elastic field is expressed generally by applying forces needed to restore region to original dimensions, forces being then a surface layer of body force in infinite solid. Removal of this is readily evaluated in Newtonian and direct potentials of uniform matter filling region. Stress just outside region is obtained by Poincaré theorem on discontinuities of second derivatives of potential. If region is ellipsoidal, stress inside it is uniform, and expressed in elliptic integrals. It is annulled, completely or in part, by superposition of a uniform field in the whole solid, leading to problem of ellipsoidal inclusion of different elastic constants.

Paper constitutes an important simplification and unification of inclusion and cavity problems. Many results of interest in dislocation theory, and some in viscosity, and thermal stress are obtained. J. N. Goodier, USA

1615. Baker, G. S., Internal friction in the presence of static stress, *J. appl. Phys.* **28,** 6, 734–737, June 1957.

The internal friction of pure lead, copper, and aluminum single crystals was measured as a function of an externally applied static biasing stress. The low strain amplitude damping of copper and lead was found to be essentially unaffected by the presence of the static stress. Aluminum differs from lead and copper in that, at room temperature, damping is independent of amplitude at low strain amplitudes ($\epsilon < 10^{-6}$). The damping in aluminum becomes strain-amplitude dependent only at higher strain amplitudes. The presence of the static stress causes this amplitude dependence to shift to lower stress amplitudes by an amount comparable to the static stress applied. From author's summary

1616. Al-Alusi, A. F., Diagonal tension strength of reinforced concrete T-beams with varying shear span, *J. Amer. Concr. Inst.* **29,** 11, 1067–1077, May 1957.

A study of the influence of variations of shear span and percentage of longitudinal steel on mode of failure, cracking strength, and ultimate strength of reinforced-concrete T-beams without web reinforcement is reported. Emphasis was placed on beams with large shear spans. The 25 beams tested included only simple-span beams under two symmetrical concentrated loads. The influence of mesh reinforcement in the flange, and that of longitudinal compression reinforcement was also investigated.

For a shear span ratio (a/d) between 4.0 and 8.0, the ratios v_u/f'_c, ultimate shearing stress to cylinder strength, and v_u/f'_c, cracking shearing stress to cylinder strength, were for all practical purposes constant. For the same a/d range, a large increase in the steel area did not affect either the ultimate shearing strength or the cracking strength. From author's summary

1617. Kihara, H., and Masubuchi, K., Studies on the shrinkage and residual welding stress of fundamental constrained joint. Part I: Effects of rod diameter, welding direction, weaving motion, peening and type of electrode on the transverse shrinkage, *Rep. Transport. tech. Res. Inst.* no. 7, 161 pp., Aug. 1953.

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 1519, 1528, 1579, 1624)

1618. Shepherd, W. M., and Gaydon, F. A., Plastic bending of a ring sector by end couples, *J. Mech. Phys. Solids* **5,** 4, 296–301, 1957.

Magnitudes of end couples required to produce yielding in a thin plate in the shape of a ring sector are found using both distortion-energy and maximum shear-yield criteria. The material is assumed to be isotropic and rigid-plastic. The solution is based on extremum principles developed by Hill [AMR **5,** Rev. 693] for such problems. Authors make no effort to suggest the engineering significance of their results. A. D. Topping, USA

1619. Lin, T. H., Creep deflections and stresses of beam-columns, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57–A–3, 4 pp.

A method for calculating deflections and stresses in beam columns subject to creep is developed. In addition to the usual assumptions of Hooke's law, plane section remains plane, and small curvature, author uses equilibrium in terms of incremental loads and moments, a stress-time relationship defined by a series of steps consisting of a constant stress internal followed by an instantaneous stress increment, and resolves the differential equation of equilibrium into two components. To eliminate the lengthiness involved in a sine series type of solution, the method of integrating operators with Green's function is used. After describing the actual steps in his method, author proceeds to solve an aluminum beam column having an ideal H section with built-in ends and operating at 600F. The central deflection-time and central, as well as end, stress-time curves are plotted.
J. P. Vidosic, USA

1620. Heimerl, G. J., and McEvily, A. J., Jr., Generalized master curves for creep and rupture, *NACA TN* 4112, 31 pp., Oct. 1957.

Generalized curves are developed on the basis of the approximate invariance of the product of minimum creep rate and rupture life. Examples for several materials show that the procedure enables satisfactory estimation of minimum creep rates from rupture life data, or vice versa, provided temperatures are sufficiently high. Similarly, times required to reach various percentages of creep strain may be calculated, provided that appreciable amounts of primary or tertiary strain are not involved.

Reviewer considers the method useful, particularly for preliminary designs involving materials which have not been fully evaluated. L. Mordfin, USA

1621. Nishihara, T., Taira, S., Tanaka, K., and Koterasawa, R., Investigation on the dynamic creep rupture of materials, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 221–224.

Authors report results on a low-carbon steel under reversed alternating bending stresses at 450 C under constant strain amplitude, using frequencies of stress cycles varying between 170 and 300 cpm. It is found that the number of cycles to rupture is independent of frequency of stress cycles. Authors indicate that this finding is not incompatible with recent findings under tension-compression or bending reversed alternating stresses at elevated temperatures where the rupture time was independent of frequency of stress cycles under constant true stress amplitude. It is shown analytically that these two findings are compatible if it is assumed: (a) At constant temperature the strain rate depends only on the stress; (b) the strain produced during the positive stress cycle is cancelled during the negative cycle, but rupture behavior depends on a critical strain energy which is related by a proportionality constant to the absolute value of the total strain; and

(c) at constant strain amplitude the plastic strain amplitude is constant. The last assumption is discussed at length.

In discussing the stress range diagram for dynamic creep rupture, authors assume, in addition to the above assumptions, that the creep rate is related to the stress by a power function. From the relations of critical absolute strain for rupture, a functional relationship between stress under static loading, mean stress, and stress amplitude under alternating stresses is found. The resulting diagram is checked with limited experimental results. The agreement is good in some cases, but large variations result in other cases. F. Garofalo, USA

1622. Shemiakin, E. I., The propagation of transient perturbances in a viscoelastic medium (in Russian), *Dokladl Akad. Nauk SSSR (N.S.)* **104,** 1, 34-37, Sept. 1955.

It is assumed that the displacement vector is propagated in accordance with a wave equation that differs from the corresponding "elastic" wave equation by adding dissipative terms. They involve a linear differential operator of the third order, one differentiation with respect to the time, two differentiations with respect to coordinates. Solutions of this equation are sought which correspond to the instantaneous application of localized stress. If the propagation of the ensuing shock wave is known in perfectly elastic materials, then the wave function appropriate to viscoelastic materials is obtained by means of an integral transformation of the "elastic" wave function. The paper is concerned only with mathematical formulations. There is no assessment in physical terms of the validity of the wave equation. It is not indicated to which problems of physics or engineering the author's mathematical arguments can be applied. For these reasons the use of the present paper is limited.

R. Eisenschitz, England

1623. Lessen, M., On the motion of a thermo-viscoelastic solid, Proc. Third Midwestern Conf. solid Mech., Univ. of Mich., Apr. 1957, 20-47.

Thermodynamic concepts are combined here with the concepts of viscoelasticity by the author's stipulation that some, but not all, of the elements (springs and dashpots) of viscoelastic models shall possess mass, energy and entropy. Further, some of the elements are assumed to correspond to physical macrostructures, others to microstructures. This theoretical framework appears to reviewer as potentially very fruitful. The proof of its success will lie in the application to definite physical problems. Present paper is mainly concerned with formal statement of principles, and with a general description of small-disturbance solutions of the type of waves. F. C. Roesler, England

Material Test Techniques

(See Revs. 1524, 1601, 1639)

Mechanical Properties of Specific Materials

(See also Revs. 1591, 1595, 1600, 1606, 1607, 1608, 1611, 1615, 1621, 1846)

1624. Murphy, A. J., Materials for aircraft structures subjected to kinetic heating, *J. roy. aero. Soc.* **61,** 562, 653-666, Oct. 1957.

The effect of saturation temperatures, attained in flight up to M = 4, on available materials including S.A.P. (sintered aluminum powder) is discussed. It is shown that S.A.P. is better than the aluminum alloys. It is argued that similar powder metallurgical products with magnesium or nickel might lead to better materials. The thermal stress is found to be proportional to $(E \cdot \alpha b \cdot d/K)$ where E = modulus of elasticity, α coefficient of thermal expansion, b specific heat, d density and K thermal conductivity. The value of the corresponding relative coefficient is unity for magnesium and aluminum alloys, 7 for titanium alloys, 16 for alloy steels, and 40 for nickel alloys. It seems therefore that the best materials for use at elevated temperatures are magnesium and aluminum alloys. A discussion of low thermal expansion alloys and the structural efficiency of materials at elevated temperatures are also included.

This survey, even though the effects of corrosion and fatigue have not been included, shows the complexity facing the designer in choosing the materials for use at elevated temperatures. It will not be possible to use one material for the whole spectrum of saturation temperatures, but the choice has to be made for the particular band in which the structure has to operate.

Y. V. G. Acharya, India

1625. Cowan, R. E., Allen, A. W., and Friedberg, A. L., Effect of temperature on modulus of elasticity of porcelain enameled steel, *J. Amer. ceram. Soc.* **39,** 9, 293-300, Sept. 1956.

The modulus of elasticity of porcelain-enameled steel specimens was measured at different temperatures. A dynamic test (the sonic method) was used for the determination of the modulus of the metal and of the metal-enamel composites. Equations and constants are presented by which the elastic constant can be calculated for any enamel thickness in the temperature range from room temperature to 500C. Graphs are also presented to show the relationship of the modulus of elasticity, temperature, and enamel-metal thickness ratio for ground-coated, white cover-coated, and direct white enameled steel specimens. From authors' summary

1626. Heller, Yu. A., The determination of the mechanical properties of tool steels (in Russian), *Zavod. Lab.* **21,** 5, 594-601, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7967.

The different forms of mechanical test (tensile, compression, torsion, etc.) are reviewed and evaluated, from the aspect of determining the parameters which are influenced by the structural characteristics of hard-tempered tool steels.

It is concluded that the most suitable test for this purpose is the bending test on prismatic and cylindrical samples with a ratio of length to maximum dimension of the cross section > 10.

It is suggested that the parameters best characterizing the properties of steel samples are the "breakdown stress," long known and used in the technical testing of cast iron, and the maximum bending deflection.

The "breakdown stress" in this sense is calculated by the empirical formula

$$\sigma = \frac{M}{\alpha W} \quad (1 \leqslant \alpha \leqslant 1.5)$$

The abstractor is of the opinion that the paper contains a number of debatable statements. K. K. Likharev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1627. Blumberg, H. S., Metallurgical considerations of main steam piping for high-temperature, high-pressure service, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-157, 24 pp. + 14 tabs. + 5 figs.

1628. Corelli, R. M., The production of titanium and its first application in aircraft construction. Part I and II (in Italian), *Aerotecnica* **35,** 5, 235-248, Oct. 1955; **35,** 6, 298-306, Dec. 1955.

1629. Robins, L., and Grala, E. M., Preliminary investigation of the effect of surface treatment on the strength of a titanium carbide-30 percent nickel base cermet, *NACA TN* 3927, 16 pp., Feb. 1957.

1630. Muckle, W., Strength: the influence of proportions on the behavior of partial superstructures constructed of aluminum alloy, *Shipbuilder* **63,** 576, 245–251, Apr. 1956.

1631. Kattus, J. R., Structural materials for missile applications at very high temperatures, *Jet Propulsion* **27,** 6, 644–648, June 1957.

Some short-time mechanical properties of copper, iron, molybdenum, tantalum, and graphite were determined at temperatures up to the melting points of the metals and up to 5200 F for the graphite. These data are intended for use in the design of missile components that are exposed to aerodynamic heating. For periods of time up to 5 min, the load-carrying abilities of tantalum and molybdenum exceed those of iron and copper at equal temperatures. Although tantalum and molybdenum have appreciable strength in the temperature range 4000 to 5000 F, their service lives are limited because they are rapidly oxidized at these temperatures. Graphite has relatively low strength at room temperature, but it retains this strength with increasing temperatures up to 4400 F and higher. The graphite is oxidized at a much slower rate than the tantalum and molybdenum. In addition to mechanical and chemical properties, thermal properties must be considered in choosing materials for missile structures.

From author's summary

1632. Kuenzi, E. W., Mechanical properties of glass-fabric honeycomb cores, *U. S. Dept. Agric., For. Prod. Lab. Rep.* 1861, 12 pp. + 2 tables + 31 figs., Mar. 1957.

Report presents the results of tests of commercially produced glass-fabric honeycomb cores for use in structural sandwich construction. Detailed descriptions of core materials and testing procedures are given. Included are results of tests of core at 73 F and 50% relative humidity and after exposure for 60 days at 100 F and 100% relative humidity. Relationships are given for various core properties in different directions, but it was not possible to show a good relationship between core strength and core density.

Design values of core properties, based on tests of commercial core samples at 73 F and 50% relative humidity and at 100 F and 100% relative humidity, are presented in tabular form and as stress-strain curves. From author's summary

1633. Morrow, J. D., and Viest, I. M., Shear strength of reinforced concrete frame members without web reinforcement, *J. Amer. Concr. Inst.* **28,** 9, 833–869, Mar. 1957.

Experimental and analytical studies reported in this paper have shown conclusively that the strength of a reinforced- concrete frame member without web reinforcement is affected by shear through the formation of diagonal tension cracks. If the percentage of longitudinal reinforcement is small or the shear span is very long, a member without web reinforcement fails in flexure without prior formation of diagonal tension cracks; in such case, strength of the member is unaffected by shear. If, however, a diagonal tension crack forms, the strength of the beam is usually lower than that corresponding to flexural failure. Depending on its make-up, such member may fail either simultaneously with the formation of the diagonal tension crack or it may fail at a higher load. The first type of failure is designated as diagonal tension failure; the second is designated as shear compression failure. The relationship between flexural, diagonal tension, and shear compression failures is discussed in detail.

The tests included 33 knee frames subjected to combination of axial compression, shear, and moment, and 38 stub beams subjected to moment and shear. In all knee frames the axial load was equal to the external shear. The major variables were the length of shear span, the strength of concrete, and the percentage of reinforcement.

Analytical expressions are presented for predicting the diagonal tension cracking load and shear compression strength. The diagonal tension cracking load is expressed in terms of the nominal shearing stress, and the shear compression strength is expressed in terms of the shear moment capacity.

From authors' summary

1634. Protze, H. G., Structural refractory concrete, *J. Amer. Concr. Inst.* **28,** 9, 871–887, Mar. 1957.

Theoretical and practical problems in the construction of jet-engine test cell exhaust structures are considered, including the development and use of proper materials, mixtures, equipment, and methods for installation of durable structural refractory lightweight aluminous cement concretes. Author draws from laboratory and field experiences on four projects in recommending current optimum techniques for such work.

From author's summary

1635. Francois, M., Study of the effect of thermal shock upon refractories. Parts 1, 2, 3 (in French) *Chaleur et Industrie* **37,** 371, 143–156, June 1956; **37,** 372, 195–207, July 1956.

1636. Bergstrom, S. G., An experimental study of the relation between the properties of fresh and hardened concrete, *Swedish Cem. Concr. Res. Inst. Bull.* no. 28, 49–74, 1953.

1637. Shinoda, G., Kajiwara, N., and Kawabe, H., Dynamical behaviour of a nylon climbing rope, *Technol. Rep. Osaka Univ.* **6,** 43–52, Mar. 1956.

Dynamic behavior of a nylon climbing rope was studied. Nylon 11mm withstands up to $H/L = 0.3$ for a falling weight of 55kg, H being the height of the falling weight and L the length of the rope. These correspond to impulsive load of nearly 600 kg for both ropes. Calorimetric study was made during shock test and compared to the result of the measurement of temperature rise during statical tension test. Nearly 600 kg, which coincided with above figure, was obtained. Nylon ropes show good characteristics for shock loading but they break easily by lateral file action of a sharp rock edge. This is a result of its low melting point, and fusing of the filament at the fracture is always observed.

From authors' summary

1638. Landstreet, C. B., Ewald, P. R., and Simpson, J., The relation of twist to the construction and strength of cotton rovings and yarns, *Text. Res. J.* **27,** 6, 486–492, June 1957.

1639. Smith, J. C., McCrackin, F. L., and Schiefer, M. F., The impact-absorbing capacity of textile yarns, *ASTM Bull.* no. 220, 52–56, Feb. 1957.

The limiting breaking energy density or energy per gram of yarn required for an immediate impact break is suggested as a suitable parameter for characterizing the impact-absorbing property.

From authors' summary

1640. Reinhart, F. W., Good, C. L., Turner, P. S., and Wolock, I., Comparison of mechanical properties of flat sheets, molded shapes, and postformed shapes of cotton-fabric phenolic laminates, *NACA TN* 3825, 60 pp., Jan. 1957.

1641. Morris, R. E., and Holloway, J. M., Evaluation of a microhardness tester, *ASTM Bull.* no. 222, 45–50, May 1957.

Tests on rubber using an ISO instrument designed for specimens of odd size and shape gave satisfactory readings on specimens as thin as 1/64 in. or with a convex surface having a radius of 1/32 in. From authors' summary

1642. Lerch, W., Plastic shrinkage, *J. Amer. Concr. Inst.* **28,** 8, 797–802, Feb. 1957.

1643. Crawford, Sheila M., Some elastic properties of organic glasses in the transition region from solid to liquid at ultrasonic

frequencies, *Proc. phys. Soc. Lond.* (*B*) **69,** 444, 1312–1318, Dec. 1956.

Measurements have been made of the dynamic shear properties of four organic glasses at a frequency of 4 megacycles per second and over a wide temperature range covering the softening region. The behavior of the shear modulus is in accord with the chemical nature of these materials. Correlation of these results with measurements of the velocity of longitudinal waves at the same frequency suggests that there is a relaxation in the bulk modulus between the solid and liquid state, as has been reported by Kuhn and Vielhauer, but at a somewhat lower temperature than the relaxation in the shear modulus. From author's summary

1644. Bass, R., Rossberg, D., and Ziegler, G., The elastic constants of ice (in German), *Z. Phys.* **149,** 2, 199–203, 1957.

1645. Forster, B., Tests to determine the adhesive power of passenger car tires, *NACA TM* 1416, 36 pp., Aug. 1956.

Experimental data on braking coefficients of friction and cornering characteristics for automobile tires are presented. Although the particular types of tires investigated are not of direct interest to the aircraft industry, the data do serve to indicate certain basic aspects of tire behavior and should be of interest to those concemed with the study of tire braking and cornering characteristics. The effects of the following factors are indicated: (a) forward speed, (b) tire loading, (c) tire pressure, (d) form stiffness of tire, (e) tire size, (f) tread pattern, (g) road surface. From author's summary

Plasticity, Forming and Cutting

(See also Rev. 1626)

1646. Ernst, H., and Haggerty, W. A., The spiral point drill—a new concept in drill point geometry, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-98, 11 pp.

After stressing the importance of drilling operation and the fact that the design of conventional twist drills has remained unchanged for over a century, writers analyze the deficiencies of this design, that is, gradual reduction of acting rake angle down to a very large negative value close to the drill center, and further, the lack of any centering action of the chisel edge. Although attempts have already been made to modify twist drill geometry, these attempts consisted merely in increasing rake angle close to drill center, with no improved centering action.

After this analytic and constructive criticism, the writers suggest an original new geometry of a "spiral point" drill, with an assured centering action and increased active rake values over the conventional "chisel point" drill geometry.

To be practical they describe a newly developed machine for grinding of spiral point drills. They also describe their own very interesting experimental work, showing the difference between conventional chisel-point drills and new spiral-point drills in chip formation, torque and thrust forces, dimension holding and performance figures.

This report is very well and carefully done and includes a lot of scientific information which, if correctly applied, will bring dollars to the machine shop. The only criticism which might be brought up consists in limiting the bibliographical references to English language publications. Reviewer suggests to interested readers the study of German work of Prof. H. Schallbroch on "Drilling and drilling machines," including rich references (Carl Hanser Verlag, Munich, 1951). A. Niedzwiedzki, USA

1647. Bulakh, G. I., The complex characteristics of the process of turbine drilling (in Russian), *Neft. Kb-vo* no. 3, 14–20, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5780.

The basic ways to increase the output of turbine drilling are given as reliable. For the qualitative analysis of the process of turbine drilling, from the point of view of functions derived from the rpm, "complex characteristics" are built up—graphs of the power of the turbine and "face" (to be drilled), graphs of available and required moments.

The power lost is determined as the power of the forces of friction on the pivot at a constant (as regards amplitude) coefficient of friction.

Examples are given of "complex characteristics" for various types of drills and rock strata.

By comparing the characteristics of the maximum potentialities of the "face" and of the turbine, and the rpm corresponding to these maxima, ways are made clear for the increase of output of the chisel and of the turbo-driller, and recommendations are framed for the selection of their parameters.

F. L. Litvin
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1648. Daasch, F. J., Eisler, S. L., McHenry, W. D., and Paton, R. K., Evaluating cutting fluids in accelerated machining tests, *Lubrication Engng.* **13,** 9, 516–520, Sept. 1957.

1649. Sudholz, L. H., Cutting fluids: fundamentals and evaluation, *Lubrication Engng.* **13,** 9, 509–515, Sept. 1957.

1650. Creveling, J. H., Jordan, T. F., and Thomsen, E. G., Some studies of angle relationships in metal cutting, *Trans. ASME* **79,** 1, 127–138, Jan. 1957.

1651. Robinson, R. L., Temperature effect on formations during jet perforating, *J. Petr. Technol.* **9,** 5, 12–14, May 1957.

An investigation into the thermal reactions during jet perforating has been conducted over a period of years. Theoretical considerations have been investigated and correlated to experimental laboratory tests. The tests have been conducted under a variety of simulated well conditions and into sandstone, limestone, and dolomite cores. Various well fluids were used in the tests. Jet charges contained in steel guns and self-contained or directly exposed jet charges were both used in this investigation.
From author's summary

1652. Neppiras, E. A., and Foskett, R. D., Ultrasonic machining; II. Operating conditions and performance of ultrasonic drills, *Philips tech. Rev.* **18,** 12, 368–379, 1956/57.

Machining by means of ultrasonic vibrations is finding widening fields of application. Part I [title source **18,** 325–334, 1956/57] of this article gave an introduction to this technique and described some of the ultrasonic drills developed by the Mullard Research Laboratories. The present (concluding) article considers in some detail the factors which are important with regard to cutting speeds, accuracy, and surface finish. A brief comparison is made with other special techniques, notably that of electro-erosion. From authors' summary

1653. Berezantsev, V. G., Limiting equilibrium of a cohesive medium under spherical and conical dies (in Russian), *Izv. Akad. Nauk. SSSR, Otd. tekh. Nauk* no. 7, 70–74, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5421.

An examination of the axially symmetrical problem of limiting equilibrium of a cohesive medium under smooth spherical and conical dies. The medium is assumed to be imponderable, and to have an internal friction ρ. The investigation was undertaken to determine the relationship between the coherence k of the medium and the pressure P on the die which brings about a state of limiting equilibrium of the medium under the die.

Author determines the total vertical pressure P on the die by the method of numerical integration of the equations of limiting

equilibrium, based on the plotting of a network of slip lines for various values of ρ. In this the numerical values of the impression radius a of the die and of the cohesion k are not given; the coordinates of the nodes of the network are determined in fractions of a, and the values of the stresses in fractions of k.

The required relationship of the cohesion to the value of the pressure on the die is expressed by the formula

$$k = \frac{P}{Na^2}$$

where N is a function of ρ.

The numerical values of this function are given for a sphere and a cone.

For convenience in calculating k according to the values of P and b measured by experimental means (b is the depth of penetration of the die) in the form given, it is necessary to put the following for the sphere and cone respectively:

$$a = \sqrt{b(2R - b)}, \qquad a = b \cot \alpha$$

where R is the radius of the sphere and α is the angle of inclination of the generatrix of the cone to the horizontal.

A. I. Govyadinov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1654. Rosenberg, L. A., Pressure of a solid body on a plate (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR*, **21**, 151–155, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7718.

The problem is examined of the pressure of a die, the surface of which, over the area of contact, is approximated by a polynomial of even-numbered order, on a constrained and a freely-supported, circular flat plate.

Author obtains a transcendental equation for determining the radius of the contact area, and an expression for the bending deflection at the center of the plate. Restricting consideration to small deflections of the plate, author determines the distributed load for different cases of contact.

M. M. Filonenko-Borodich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1655. Shevchenko, K. N., Stresses and deformation for some simple arrangements of sheet stamping (in Russian), *Sb. nauchn. rabot Mosk. inzh.-fiz. in-ta* no. 8, 80–96, 1954; *Ref. Zh. Mekh.* 1956, Rev. 5368.

Determination of the stresses and deformation in a semifinished piece of deep sheet drawing on very approximate assumptions; for example, the start of the flow of the metal is equated to the moment of actual termination of the moulding of the bottom of the cover, disregarding friction between the tool and the blank, etc. The parameters of the practical technology of deep sheet drawing (optimum radii of rounding of the die, clearance and taper, pressing stress and drawing, etc.) are not determined. Terminological inaccuracies are permitted (multi-lateral hydrostatic pressure, elastic stresses, etc.)

G. A. Smirnov-Alyaev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1656. Tarutin, V. Ya., The hydrodynamic analysis of the pouring process in the manufacture of large thin-walled castings (in Russian), Thesis, Moscow Inst. Aero. Engng., Moscow, 1956; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7579.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Hydraulics; Cavitation; Transport

(See also Revs. 1586, 1612, 1613, 1759, 1831)

Book—1657. Leliavsky, S., Irrigation and hydraulic design, Vol. II., New York, The Macmillan Co.; London, Chapman & Hall, Ltd., 1957; xvi + 864 pp. $60.

The first volume of this excellent treatise [AMR **9**, Rev. 777] was dedicated to general principles of hydraulic design. Irrigation works are the content of this second large volume. Major chapters are on barrages and regulators, syphons, weirs, spillways, bridges, gates, aqueducts. Chapter on planning and designing a perennial irrigation scheme describes canals, drains, head sluices, canal outlets, modules, the water-duty problem, seepage from canals. Storage dams are not included in this volume.

The book was planned on a large scale; it is a real "opus magnum". Text is illustrated by complete drawings of structures, on 69 extra plates, with many details, and with detailed computations. Steel bridges alone cover 100 pages. It seems that some questions could better have been transferred into the first volume, particularly discussions on old formulas for submerged weirs. Drawings are mostly from author's work in Egypt, but American and Indian experience is widely used, e.g., Parshall measuring flume.

Author expresses his wish to see his book on the designer's desk; it will be regrettable if high price proves to be a prohibitive factor.

S. Kolupaila, USA

Book—1658. Blench, T., Regime behaviour of canals and rivers, London, Butterworths Scientific Publications, 1957, xii + 138 pp.

Regime canals with mobile boundaries are defined as self-adjusting to a certain equilibrium. Problem of designing nonsilting, nonerodible channels is of great importance in irrigation work. Knowledge of laws of regime behavior is necessary in every intervention with natural river course. Studies were originated in India by Kennedy (1895), and continued by Lindley (1919), Lacey (1929–1948), Inglis (1949), and the author, who was previously director of irrigation research in Punjab and is a recognized authority in this intricate field.

Author introduces two specific terms—a bed factor and a side factor—and develops three formulas for determination of depth, width, and slope of a regime channel. Formulas proved satisfactory for subcritical flow in a straight canal of small bed-load charge, when width is more than three times depth. Further on, author corrects these formulas for large bed-load charge and applies them to meandering natural rivers. He tries to justify dimensions of his formulas by analysis of dynamic aspects of regime flow. Every hydraulic engineer will read with interest this little, comprehensive, and perfectly edited book.

S. Kolupaila, USA

Book—1659. Leliavsky, S., An introduction to fluvial hydraulics, London, Constable & Co., 1955, xii + 257 pp.

Attractively edited book contains enormous amount of problems on natural channels and stable canals: Traction and suspension, drag and lift, dunes and ripples, convergent and divergent currents, side-slope stability, meandering and shifting of meanders, scour criteria, relation between river slope and size of silt, mechanical explanation of silt suspension, drag theory of bed load, empirical approach to silt transportation, helicoidal flow in bends of meandering rivers, five Fargue laws, Lane's comparative analysis, and many more questions. Book is a remarkable synthesis of knowledge compiled by scientists of all nations. Author is to be commended for recalling with some detail the pioneer work done by his father N. S. Leliavsky (1863–1905), a famous Russian hydraulic engineer.

Book is of great importance to hydraulic engineers and hydrologists. Reviewer cannot approve the use of isovels instead of correct term isotachs. A few names, such as Beyerhaus, Nikuradse, are to be corrected. S. Kolupaila, USA

1660. Zhulaev, R. Zh., and Arykova, A. I., Hydraulic and deposit conditions of crevice orifices (in Russian), *Izv. Akad. Nauk Kaz. SSR, Ser. energ.* no. 8, 67–74, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5191.

The results are given of experiments made in 1950 and 1951 on crevice orifices in the bottom irrigation galleries. A crevice was made over the whole width of the water collector from the side of the upper level in the horizontal, vertical, and inclined planes. The size of the orifices was up to 100 mm, the discharges were up to 25 l/sec, and the parameter of kineticity of the appropriate flow was between 0.3 and 10. The results are given in the form of graphs and one table (for pressures on the dam). There are no theoretical comparisons in the paper.

In the relation to the horizontal crevice a 50% increase is noted in the velocity below the crevice. The discharge coefficient of the crevice, which was calculated in relationship to the full pressure, varies from 0.8 for the narrowest crevice to 0.25 – 0.3 for a wide crevice. The influence of the parameter of kineticity is not found in practice, although it is noted on page 70. For an orifice in the vertical plane, the discharge coefficient is about 0.85 to 0.90.

Study of deposit conditions shows a considerable reduction of the pump intake into the gallery. Graphs are given of the specific intake of deposit in the crevice and into the water-collecting gallery, as well as the granulometric curves of the deposit. The equation given on page 71 of the curve of the specific intake of the deposits into the crevice does not agree with the graph of figure 7 (curves 1, 2).

No mention is made of the fact that the suggestion for fitting an additional trough in the upper portion of the cascade (covered cascade) was made by T. G. Gegeliya [*Tbilis n.-i in-t sooruzh. i gidroenergetiki* 1944]. M. A. Mostkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1661. Latyshenkov, A. M., Choice of design and calculation of flow-guiding piers on catchments (in Russian), *Trudi Gidravl. labor. Vses. n-i in-ta vodosnab. kanaliz. gidrotekhn. sooruzh. i. inzh. gidrogelo* no. 4, 38–72, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5184.

First of all, a short survey is made of the methods of designing the stream-guiding piers of bridge passages. Further, a description is given of the result of tests made in the Kuchinsk Hydraulic Laboratory on a model of a one-sided schematized catchment of a river with a channel, on a scale of 1–100. The dimensions of the model are 4.4 × 12m.

In the author's opinion, the most rational design of the catchment should insure: continuous surface and bottom flows with uniform variations of the water surface and value of the velocity along the piers; the least value of the curvature of the free surface of the water at the bridge buttress; and the most uniform curve of velocity distribution over the width of the catchment portion of the bridge opening. The experimental investigation of the flow conditions about the piers of seven differing designs showed that the above-mentioned demands are most fully satisfied by piers which are described by an ellipse having a relation of the semi-axes of 1.5 to 2.5.

A method is given for constructing the recommended types of piers and for calculation of their dimensions.

V. V. Fandeev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply

1662. Indri, E., Model studies of throttled inlet sections for surge tanks (in Italian), *Energia Elett.* **34,** 6, 554–568, June 1957.

The assumption of the coefficients of resistance for the throttling of cross section is uncertain without model tests of knowledge of exact empirical factors. For this there exist many references.

Author has made comprehensive experiments on 150 various-shaped pieces of restricted cross sections and has worked out the concerned coefficient for calculating the additional head loss.

P. Franke, India

1663. Strandhagen, A. G., and Seikel, G. R., Lift and wave drag of hydrofoils, Proc. Fifth Midwestern Conf. Fluid Mech., Univ. of Mich., Apr. 1957, 351–364.

A theory is presented to predict lift and wave drag of hydrofoils moving at finite depth beneath free surface of perfect fluid. Analytical lifting-line model is proposed which satisfies both free surface and Kutta's conditions. Free-surface correction factor arises in analysis to take care of effect of finite depths and speeds. Comparison with existing experimental data is good.

From authors' summary by A. Balloffet, USA

1664. Kerr, S. L., and Rosenberg, K., An index of cavitation erosion by means of radioisotopes, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-64, 4 pp.

The optimum output of a hydraulic turbine may be fixed by cavitation erosion resulting from high discharges. Quantitative evaluation of such erosion usually requires several months of operation. Authors describe a short series of tests in which radioactive paint was applied to an eroded runner, after which the unit was placed in operation. The measurement of the runner radioactivity at periodic intervals served to indicate the loss of material and index of cavitation for various operating conditions. Results show a consistent variation of erosion rate with turbine output.

Reviewer finds method novel but conclusions questionable on a quantitative basis owing to difference in erosion resistance between runner metal and radioactive paint.

W. DeLapp, USA

1665. Shal'nev, K. K., Intensity of cavitation erosions (in Russian), *Izv. Akad. Nauk SSSR, Otd. tekh. Nauk* no. 1, 3–20, Jan. 1956.

A shortened version of a paper presented by author at the international symposium on "Cavitation in Hydrodynamics," National Physical Laboratory, Teddington, England, 1955. [See AMR **10,** Rev. 176.] A. H. Armstrong, England

1666. Guth, W., Formation of shock waves in cavitation (in German), *Acustica* **6,** 6, 526–531, 1956.

Paper is an exposition of results on proximate pressures and shock-wave formation associated with collapsing cavitation bubbles and the diffusion of air into oscillating cavities inferred from the theoretical results of Rayleigh [*Phil. Mag.* **34,** p. 94, 1917], Noltingk and Neppiras [*Proc. phys. Soc. (B)* **63,** p. 674, 1950; AMR **5,** Rev. 1760], and Blake's hypothesis of rectified diffusion [Harvard Univ. Acoust. Res. Lab. T.M. 9, 1948]. It is a supplement to author's previous description of schlieren photography of the shock waves propagated by collapsing cavities [AMR **8,** Rev. 828].

P. Eisenberg, USA

1667. Margulis, W., McGowan, J. A., and Leith, W. C., Cavitation control through diesel-engine water treatment, *SAE Trans.* **65,** 331–336, 1957.

Incompressible Flow: Laminar; Viscous

(See also Revs. 1715, 1718, 1719, 1721, 1722, 1739, 1742, 1746, 1752, 1754, 1782, 1824, 1826, 1828, 1829, 1830, 1832)

1668. Sukharevsky, I. V., the effective calculation of velocity and circulation in a potential flow through a cascade (in Russian), *Trudi Kharkovsk. politekhn. in-ta* **5,** 1, 57–66, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7432.

On the basis of the formula given by N. E. Koehin [*Prikl. Mat. Mekh.* **5,** no. 2, 1941; **11,** no. 1, 1947], author sets up a system of three integral equations for the velocity at the cascade profile, and a general scheme of solution by progressive approximation in the plane of the cascade is presented. Proof is given of the convergence of these approximations by analysis of the distribution of the characteristic values of these equations.

An example is given for the calculation of the flow around a cascade of circles of unit radius with a pitch of 1.25. In the third approximation, the nondimensional value of the circulation is obtained as 1.94, against a rigorous value of 2.00.

G. Yu. Stepanov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1669. Nechayev, S. V., The simulation of a circulation flow by an electro-hydrodynamical analog in accordance with the Chapligin-Joukowsky postulate (in Russian), *Trudi Ufimsk. aviats. in-ta* no. 1, 28–39, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev 7433.

An EGDA arrangement in a balancing circuit is used in an electrolytic bath to investigate the circulation flow around a cylinder, a flat plate, and an airfoil, in accordance with the Chapligin-Joukowsky postulate.

The two-dimensional flow of an incompressible fluid around a profile with a velocity circulation is obtained in the model by the superposition of plane-parallel and circulatory fields for which, in the EGDA arrangement, two pairs of busbars are used [see also: A. N. Patrasher, Gidromekhanika; Naval Publications of the Ministry of the Navy, SSSR, 1953, p. 262].

N. I. Druzhinin
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1670. Kaplun, S., and Lagerstrom, P. A., Asymptotic expansions of Navier-Stokes solutions for small Reynolds numbers, *J. Math. Mech.* **6,** 5, 585–593, Sept. 1957.

Paper deals with problem of finding asymptotic expansion of Navier-Stokes solutions which are uniformly valid for the entire flow field for small values of Reynolds number. This problem differs from the case of expansions for large Reynolds numbers in that a simple matching of outer and inner expansions is not possible. Instead, a generalized matching principle is introduced, making use of an intermediate expansion. The method is illustrated by application to the flow past a sphere.

G. M. Low, USA

1671. Kaplun, S., Low Reynolds number flow past a circular cylinder, *J. Math. Mech.* **6,** 5, 595–603, Sept. 1957.

The matching principle discussed in the paper by Kaplun and Lagerstrom (preceding review) is applied to the flow past a circular cylinder at low Reynolds number. The general two-dimensional problem is also discussed.

G. M. Low, USA

1672. Lagerstrom, P. A., Note on the preceding two papers, *J. Math. Mech.* **6,** 5, 605–606, Sept. 1957.

The papers by Kaplun and Lagerstrom, and by Kaplun (preceding two reviews) are discussed. It is pointed out that, while application of the generalized matching principle was made to a solution of the expansion problems of Navier-Stokes solutions for low Reynolds numbers, the ideas presented may apply to a large class of singular perturbation problems.

G. M. Low, USA

1673. Lakshmana Rao, S. K., Addition of axially symmetric motions of viscous liquids, *Proc. Ind. Acad. Sci.* **45,** 6, 418–423, June 1957.

Author extends previous work [see AMR **4,** Rev. 1643; **5,** Rev. 3139; **11,** Rev. 161] to include necessary and sufficient conditions for superposability of incompressible, axisymmetric viscous flow having a velocity component normal to the meridian plane. No new examples of such flows are given.

W. L. Haberman, USA

1674. Bhatnagar, P. L., and Verma, P. D., On superposable flows, *Proc. Ind. Acad. Sci.* **45,** 5, 281–292, May 1957.

Authors derive conditions for superposability of two-dimensional and axisymmetric, incompressible flows. Most of the results have previously been given (e.g. AMR **4,** Rev. 1643; **5,** Rev. 3139; **11,** Rev. 161). Examples of two-dimensional superposable flows (vortex, spiral vortex, vortex doublet, and radial flow) are presented.

W. L. Haberman, USA

1675. du Neufville, A., The dying vortex, Proc. Fifth Midwestern Conf. fluid Mech., Univ. of Mich., Apr. 1957, 365–375.

This paper provides a mathematical description of the diffusion of the vorticity in a Helmholtz vortex. It is shown that the fluid finally comes to rest in a finite region. This solution is found from the Navier-Stokes equation for an incompressible fluid, whose geometry is axially symmetric. A transformation is introduced which, if discreet eigenvalues are assumed, leads to a solution in inverse powers of time and Laguerre polynomials in the new variable. (It should be noted that there is a typographical error in the definition of the Laguerre polynomial, the $(n + a)$! in the denominator should be replaced by $(k + a)$!).

Reviewer believes that this solution is of practical use for calculating the rate of decay of shed vorticity from lifting wings at large times and may thus be of some practical importance. The short time solutions can be found by expressing the Laguerre polynomials in terms of the asymptotic representation of hypergeometric functions. It would seem that another set of fundamental solutions could be applied to the same problem by use of the Fourier-Bessel integral [see Bateman, H.; "Partial differential equations;" New York, Dover Publications, Inc., 1944, pp. 338–345 and pp. 398 ff.].

E. E. Covert, USA

1676. Carrier, G. F., and DiPrima, R. C., On the unsteady motion of a viscous fluid past a semi-infinite flat plate, *J. Math. Phys.* **35,** 4, 359–383, Jan. 1957.

The viscous incompressible flow past a semi-infinite flat plate is investigated when the flow at infinity is $U_0 + U_1 \exp(i\omega t)$. The analysis is based on a system of equations derived by a modified Oseen linearization of the equations of motion. It is found that when $(\omega\nu)^{1/2} >> U_0$ and U_1, the flow field consists of the sum of a mean flow (due to U_0) and an oscillatory motion [due to $U_1 \exp(i\omega t)$]. The phase advance in the oscillatory motion is $\pi/8$ at the leading edge and increases monotonically to $\pi/4$ in a distance approximately given by $(\omega/2\nu)^{1/2} x \geq 2.5$. The result for $(\omega/2\nu)^{1/2} x \geq 2.5$ is a shear-wave-type solution and corresponds to an infinite lamina performing harmonic oscillations in a viscous fluid.

The problem when the interaction of the mean motion and the oscillatory motion can not be neglected is also considered.

From authors' summary by S. I. Pai, Germany

1677. Senoo, Y., The boundary layer on the end wall of a turbine-nozzle cascade, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-172, 16 pp.

Stationary cascade experiments are described which reveal the end-wall (or casing) boundary layer to be laminar at the throat of the nozzle, even when the upstream boundary layer is turbulent. Theoretical considerations indicated that the influence of the upstream boundary layer on the conditions at the end wall would be expected to be small. Satisfactory agreement is shown between the theoretical estimates and measured boundary-layer profiles.

J. V. Becker, USA

Compressible Flow, Gas Dynamics

(See also Revs. 1519, 1542, 1624, 1666, 1684, 1747, 1753, 1755, 1756, 1758, 1803, 1824)

1678. Thomas, T. Y., The growth and decay of sonic discontinuities in ideal gases, *J. Math. Mech.* **6,** 4, 455–469, July 1957.

Author's article deals with the following: A space is filled with an ideal gas, devoid of viscosity and thermal conductivity. In this space there is a surface on both sides of which velocity, pressure and density are the same; but at least one of the first derivatives of these quantities with respect to the space coördinates are discontinuous across this surface. If this particular surface, called sonic wave, moves through the gas, it is possible that the discontinuities damp out or become infinite. In the latter case the sonic wave will terminate in a shock, and there will be discontinuities not only in the derivatives but in the values of velocity, pressure and density itself.

Author shows that decay or infinite growth of the sonic wave depends on the initial values of the discontinuities and on the initial curvature of the surface. Besides this he finds also an expression for the relative velocity-, pressure- and density-increase in a point of the space after the sonic wave has passed.

J. H. Van de Stadt, Holland

1679. Robineau, B., Quick graphical methods in compressible flow problems, *Aircr. Engng.* **29,** 336, 39–41, Feb. 1957.

1680. Fraenkel, L. E., On the unsteady motion of a slender body through a compressible fluid, *Aero. Quart.* **6,** 1, 59–80, Feb. 1955.

Ward's slender-body theory is extended to examine the unsteady motion of a slender body through a fluid at rest. The cross-sectional area and shape of the body, its forward velocity and its lateral motion are all arbitrary functions of time, but are subject to the restrictions of small disturbances. The length of the body is fixed. An approximate velocity potential is obtained by the joint use of two integral transforms, and the accuracy of this potential is discussed in some detail. General expressions for the aerodynamic forces acting on the body are derived in terms of a coordinate system which moves forward with the body in the mean direction of motion, but is fixed laterally. These expressions are then transformed, for the particular case of an oscillating rigid body moving forward with variable velocity, to expressions in terms of coordinates referred to the body axes. (The former coordinate system makes possible a fairly compact general treatment, whereas the latter is more convenient if the solution of a particular rigid-body problem is required.) Finally, arguments are advanced to justify the application of the slender-body theory to wings of slender planform whose trailing edges are perpendicular to the direction of motion, and results are given for an oscillating wing moving forward with variable velocity.

From author's summary

1681. Skochinsky, A. A., Modern conceptions on the nature of coal and gas blows in pits and methods for their prevention (in Russian), *Ugol'* no. 7, 4–10, 1954; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7250.

Author classifies a number of specific dynamic phenomena occurring in coal mines: (1) rock burst; (2) coal and gas blows; (3) coal falls with liberation of gases (methane, carbon dioxide); (4) coal extrusions; (5) gas blows from roof or floor of the seam.

Author believes that present hypotheses explaining these phenomena either by rock pressure only, or by the pressure of the gases occluded in the coal seams only, are inconclusive. He considers that both these factors are essential to explain such sudden bursts and blows and that much depends on the structure of the coal in the seam.

His researches, made principally in the Donbass coal field, have confirmed the author's suppositions. In conclusion, means of controlling and preventing bursts and falls are described and discussed.

K. P. Stanyukovich

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1682. Ludewig, M., On the flow of compressible media through straight cascades (in German), *Forsch. Geb. Ing.-Wes.* **22,** 6, 181–191, 1956.

For flow without energy loss, the relation between the velocity before and behind a cascade with flat plates is calculated. For a given cascade the possible inflow is limited by two causes: The velocity cannot cross the velocity of sound, and if the velocity of the inflow is higher than the sonic velocity, the shock wave at the entrance must always lie within the cascade. The limits of the possible inflow are calculated and given in diagrams. The influence of energy loss is calculated too. Experiments in a water tank, using the analogy between the waves in a compressible gas and the waves on the surface of water, as well as schlieren pictures, agree very well with the theory.

A. Betz, Germany

1683. Tamaki, F., Experimental studies on the stability of the transonic flow past airfoils, *J. phys. Soc. Japan* **12,** 5, 544–549, May 1957.

Local flow fluctuations near the airfoil surface have been measured in the speed range near critical Mach number by using a Mach-Zehnder interferometer and a rotating-drum camera. Airfoils tested are Tomotika-Tamada airfoil, NACA-0012, and 10 per cent thick elliptic cylinder. Experiments show that amplitude and frequency of oscillation that appear when the local sonic speed is exceeded on the surface depend on the shape of the profile. In the cases of T.T. and 0012-airfoils, the oscillation is of small amplitude and high frequency when the maximum local Mach number on the surface is not much above unity, and the time-mean pressure distribution on the surface is smooth and shows no appreciable distortion due to shock waves. In the case of the elliptic cylinder, slow oscillation of large amplitude involving distinct shock waves appears as soon as sonic speed is exceeded on the surface.

From author's summary

1684. Berndt, S. B., On the influence of wall boundary layers in closed transonic test sections, *Flygtekn. Försöksanst. Medd.* no. 71, 78 pp., 1957.

The boundary layers at the test section walls of a transonic wind tunnel are known to reduce wall interference. An approximation for thin boundary layers leads to a modified boundary condition at the wall of the test section, expressing the normal streamline slope induced by changes in mass flow density and crossflow within the boundary layer. This boundary condition is applied to the linearized equations of subsonic flow and to the nonlinear transonic equations at choking, plane and circular sections being treated. The results of linear theory show that all corrections except the three-dimensional angle-of-attack correction are considerably reduced by the presence of the boundary layers at Mach numbers greater than 0.9, the essential part of their influence being due to the change of mass flow density with

pressure. In the case of choking, the analysis indicates that the presence of boundary layers will increase the maximum model size for which the flow can be interpreted as corresponding to Mach number one in free flight.

From author's summary by J. R. Baron, USA

1685. Kawamura, R., and Tsien, F.-H., On the stability of two-dimensional transonic potential flows, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 249–252.

The two-dimensional transonic potential flow near the surface of a body is considered when disturbances are present in the flow, the disturbances having their origin in the boundary layer or wake. The disturbance is taken to be a triangular pulse with a shock at its head (compression pulse) or tail (expansion pulse). The stability is determined by whether the disturbance increases or decreases in strength in the neighborhood of the sonic line. It is shown that only upstream moving disturbances need be considered, the downstream moving disturbances being propagated without change of strength.

The flow equation is nonlinear with time-dependent coefficients. This is solved by an approximate method using a linearized equation.

It is found that in an accelerating flow there are no disturbances approaching the sonic line against the flow. Steady accelerating two-dimensional transonic potential flows over any surface are stable for both compression and expansion disturbances produced downstream. Steady decelerating potential flows are stable for expansion pulses and unstable for compression pulses. Steady potential flows with local supersonic regions involving both accelerating and decelerating flows are unstable.

A. W. Babister, Scotland

1686. Keune, F., Results of an approximate theory for the transonic flow around twisted and cambered pointed wings, *Z. Flugwiss.* **4,** 8, 276–280, Aug. 1956.

By aid of slender-wing theory, numerical results for the pressure distribution, center of pressure, zero-lift incidence and zero-lift moment are given for a family of twisted wings. The results show that, according to the twist and the planform of the wing, large variations of the center of pressure are possible. While the ratio of lift and dynamic pressure does not depend on the wing planform, the moment of the wing and the center of pressure, however, vary with wing planform; this is also the case for cambered wings.

Numerical results are given for the center of pressure of a family of wings, whose center sections have a so-called "Birnbaum" camber. The camber of a small-aspect-ratio wing appears to be smaller than that of a two-dimensional wing, when both wings have the same location of the center of pressure.

E. M. de Jager, Holland

1687. Broglio, L., A method for solving dynamic problems of modern transonic and supersonic wings, *AGARD Publications Rep.* 38, 23 pp. + A–iv, Apr. 1956.

This paper presents a method for the general solution of dynamic problems of delta, swept or crescent wings, or those of a more general type. In the first part a structure of any type is considered, of which the influence coefficients and mass distribution are assumed to be known. Starting from these data, a method is given for a rapid and exact determination of the frequencies and modes of vibration. The second part discusses the calculation of the influence function for swept, delta or crescent wings, either solid or shell type. In the third part, the method described in the previous two parts is applied to practical problems. An Appendix shows how to determine the influence function in specific simplified cases.

From author's summary by M. V. Barton, USA

1688. Fairbairn, A. R., and Gaydon, A. G., Spectra produced by shock waves, flames and detonations, *Proc. roy. Soc. Lond.* (*A*) **239,** 1219, 464–474, Apr. 1957.

Emission spectra excited in various gases, including fuel and fuel + argon mixtures, by strong shock waves from a bursting diaphragm are compared with those given by flames and by spark-ignited and shock-ignited detonations.

Shocks through hydrocarbon or hydrocarbon + argon mixtures, without oxygen, give carbon formation and C_2 emission but not CH. Formaldehyde, ether, alcohols, carbon tetrachloride, and chloroform have also been studied. Carbon monoxide + argon mixtures give strong C_2 but no CO bands; hydrogen or oxygen only slightly quench this C_2, but mixed hydrogen and oxygen quench it strongly. Reactions involving C_2 and CH are discussed.

In detonations, OH is very strong, and C_2 and CH are weak compared with burner flames. Time records, using a photomultiplier and oscillograph, indicate that C_2 emission comes from the reaction zone of the detonation, but OH and the continuous spectrum are emitted mainly by the hot gases behind the front. The relation of the results to the propagation mechanism is briefly discussed.

Shock-excited spectra resemble those produced by flames rather than those from discharge tubes, and this appears to be a promising technique for studying fundamental processes in flames.

From authors' summary

1689. Barthel, H. O., On a mechanism for the interaction of plane traveling shock waves striking rigid grid-like structures head-on, Proc. Fifth Midwestern Conf. fluid Mech., Univ. of Mich., Apr. 1957, 171–186.

A flow model for a plane shock wave striking a grid head-on is proposed and analyzed, leading to predictions of the strengths of the reflected and transmitted shock waves over the Mach number range 1.0 to 2.4. These predictions are then compared with experimental values obtained from tests of several grid shapes in a shock tube, and the two quantities are shown to be in reasonably good agreement.

F. G. Blight, Australia

1690. Henshall, B. D., and Cash, R. F., The interaction between shock waves and boundary layers at the trailing edge of a double-wedge aerofoil at supersonic speed, *Aero. Res. Counc. Lond. Rep. Mem.* 3004, 10 pp., 1957.

A comprehensive review of the work at the National Physical Laboratory on shock-wave boundary-layer interaction has recently been published. The experiments reported were designed to investigate a further case of this interaction which was not considered earlier; namely, that occurring near the trailing edge of a double-wedge airfoil at supersonic speed. This interaction should be similar to that where the shock is generated by a wedge attached to a flat plate; indeed, the only difference between these two cases is that the downstream solid boundary of the latter is replaced by the center-line of the wake of the airfoil. Experimental results confirm that these interactions are both qualitatively and quantitatively similar and further support the physical explanations of these flow patterns given earlier; moreover, the results apply generally to airfoils with flat surfaces toward the rear.

From authors' summary

1691. Ryzhov, O. S., and Taganov, G. I., Second limiting case in the problem of strong spherical shocks (in Russian), *Prikl. Mat. Mekh.* **20,** 4, 545–548, July-Aug. 1956.

In the framework of usual strong shock treatment of a perfect gas (e.g. Courant-Friedrichs, "Supersonic flow and shock waves," 1948 ed., sections 159–161) the assumption of infinite heat conductivity is made. The energy equation away from the shock is thus replaced by $p/\rho = F(t)$ (which reduces to $kt^{-2/3}$ by similarity considerations). However, the energy equation across the shock requires an extra term, Q, the energy absorbed per unit mass.

This is reflected in the authors' parameter α which governs the conditions behind the shock—the initial conditions for the integration of the system of the two resulting nonlinear differential equations. Solutions are found numerically and compared with Sedov-Taylor solutions to the "first limiting case" [AMR 4, Rev. 1381] in figs. 2 and 3. In particular, the radial velocity drops to zero at half the shock radius, where a weak shock is assumed to join the flow to a completely calm central region. Also, the solutions appear to be very weak functions of the ratio κ of the specific heats.

M. V. Morkovin, USA

1692. Hain, K., Interaction of two one-dimensional shock waves (in German), *Z. Naturforsch.* **11a**, 5, 329–339, May 1956.

The problem of the mutual influence of traveling one-dimensional shock waves of potential importance in astrophysics is treated.

The assumption is made that the velocity and density distribution of the traveling shock waves before interaction follow the homology (similarity) solution obtained by Hafele [see Rev. 1696 this issue].

Numerical calculations are performed for various initial conditions both for head-on collision and overtaking. All cases tend quite independently of the initial Mach number (before interaction) toward the homology solution. A general conclusion is drawn as follows. The solution after collision is almost independent of the original shock strength but depends on the homology solution of the stronger shock wave only. This shows again the importance of the homogy solutions.

H. P. Eichenberger, USA

1693. Hafele, W., Note on an additional regular homology solution (in German), *Z. Naturforsch.* **11a**, 1, p. 163 (Short Notes), Jan. 1956.

An additional homology solution for one-dimensional unsteady gas flow has been found. But in opposition to the earlier homology solution [see Rev. 1696 this issue] these solutions do not satisfy the boundary conditions given by a shock.

H. P. Eichenberger, USA

1694. Hafele, W., Stability of the Guderley type spherical compression wave (in German), *Z. Naturforsch.* **11a**, 1, 183–186, Jan. 1956.

The stability of Guderley's solution with respect to the initial conditions [*Luftfahrtforshg.* **19**, p. 302, 1942] for a spherical shock wave moving toward the center is investigated by the method of limit lines. This procedure has been used by the same author [see Rev 1695 this issue] for a similar problem in the plane case.

Guderley's solution is characterized by its homology (= similarity) in that the solution is a function of a combination of the variables alone and not of the two variables separately. Since this particular solution satisfies particular initial conditions only, the question is asked whether slightly different initial conditions yield solutions which tend toward the particular homology solutions. It is found that this is actually so "near" the center of the sphere.

The procedure is essentially as follows: The new variable which leads to the homology solution is in general a function of the original two variables and a parameter which is so determined that the actual homology solution is obtained. For all other solutions this parameter is a function of time. With arbitrary initial conditions the variation of this parameter is traced as a function of time and it is shown that it tends toward the constant which is characteristic for the homology solution.

H. P. Eichenberger, USA

1695. Hafele, W., Stability of shock-wave types from the class of homology solutions (in German), *Z. Naturforsch.* **10a**, 9/10, 1017–1027, Sept./Oct. 1955.

In a previous publication [see Rev. 1696 this issue], homology solutions of the state of a gas behind a shock wave were found which satisfy special initial conditions as they may occur in a traveling interstellar gas cloud or behind the strong shock front caused by an explosion at high altitude. Numerical solutions [see Rev. 1698 this issue] indicated that the solutions with almost arbitrary initial conditions tend with time toward the special homology solutions mentioned above. Series expansion in terms of the distance from the shock front with initial conditions slightly different from those leading to the exact homology solutions show also a convergence (with time) toward the homology solution [see Rev. 1697 this issue]. In this paper it is shown analytically that solutions with arbitrary initial conditions tend with time toward the homology solutions provided these initial conditions are so that no shock waves are formed in the considered region (behind the strong shock).

Reviewer sees that, as a consequence of these findings, the homology solutions are of considerable practical interest.

H. P. Eichenberger, USA

1696. Hafele, W., Analytical treatment of plain strong unstationary shock waves (in German), *Z. Naturforsch.* **10a**, 9/10, 1006–1016, Sept./Oct. 1955.

The behavior of gases behind a strong shock with no energy supply from the back is analyzed by the method of Guderley [*Luftfahrtforschg.* **19**, p. 302, 1942]. The separation of variables (distance from shock front X and time) and simultaneous transformation of variables replace the partial differential equations (continuity, momentum, and energy) for inviscid flow by a total differential equation describing homology (similarity) solutions given generally for the spherical, cylindrical, and the plane case. The major part of the paper consists in the discussion of this differential equation for the plane case. For the ratio of specific heats $k = 1.4$, the solution is found analytically (exactly linear velocity distribution) and for other ratios by numerical integration.

These particular solutions are of considerable practical interest since numerical solutions by the method of characteristics seem to indicate [see Rev. 1698 this issue] that all solutions with almost arbitrary initial conditions tend with time toward these particular solutions.

This problem of particular "stability" of these solutions will be treated in the following paper.

Reviewer finds that this paper is a very instructive analysis of a differential equation in addition to its practical value.

H. P. Eichenberger, USA

1697. Meyer, F., Representation of strong shock waves by homology solutions, *Z. Naturforsch.* **10a**, 7, 693–697, July 1955.

The problem of the change of states (density, velocity temperature) behind a strong one-dimensional shock waves as a function of time and distance from the shock front is investigated analytically by series expansion in terms of the distance from the front. As initial values, the first terms of the series representing homology solutions [see following review] are used. A particular homology solution (characterized by $K = 0.39$) appears to be stable since the series expansion (exact solution) approaches this particular solution in time if the initial conditions were not too far from it in the first place.

H. P. Eichenberger, USA

1698. Hain, K., and Hoerner, S. V., Unsteady strong shock waves (in German), *Z. Naturforsch.* **9a**, 12, 993–1004, Dec. 1954.

The problem of a strong plane shock is considered. For various initial density, temperature, and velocity distributions behind the shock, these functions are calculated as a function of time and distance from the shock front. The results are obtained by solving the one-dimensional continuity, momentum, and energy equation in absence of viscosity by the method of characteristic using a

high-speed computing machine. It is found that all the solutions approach with increasing time the homology (similarity) solution reported by C.F.V. Weizsacher [see following review] with the parameter K (which could be chosen freely in Weizsacker's solution) = 0.39. But the solutions did not show the singularities obtained by Weizsacher's solutions.

Hafele found later [see Rev. 1696 this issue] that a singular solution exists with $K = 0.3893$ which does not show any singularity.

The article contains also a good description of the general procedure of treating a set of hyperbolic partial differential equations by means of the method of characteristics on a computing machine. H. P. Eichenberger, USA

1699. Weizacker, C. F. V., Approximate representation of strong unstationary shock waves by homology solutions (in German), *Z. Naturforsch.* **9a**, 4, 269–275, Apr. 1954.

This is the first of a series of articles which treats the behavior of a strong plane blast in a perfect gas as a function of time and space. The front of this blast is formed by a strong shock (pressure and temperature before shock negligible as compared to its values immediately after the shock) whose behavior is well-known and enters into these considerations as a boundary condition for the equations describing the phenomena behind the shock.

This work was stimulated by astrophysical phenomena (propagation of a cloud) but it applies to all plane blast propagations provided there is negligible energy input from the rear.

The three partial differential equations (continuity, momentum, and constant entropy) for unsteady one-dimensional and nonviscous flow are transformed into three total simultaneous differential equations by introducing a new independent variable $\xi = x \cdot t^{k-1}$, where x is the distance from the shock front and t the time and K is a factor which may be chosen arbitrarily. Solutions (called homology solutions) of these total differential equations were obtained by a computing machine for various values of K. These solutions satisfy the conditions at the shock front which is introduced as a boundary and initial condition. All values of K investigated lead to solutions which show singularities for finite ξ and represent therefore no exact physically realizable solutions in the whole half plane $\xi > 0$. However, several later graphical solutions with arbitrary initial conditions appeared to approach with increasing time the analytic solution obtained above with $K = 0.4$ near the shock front.

H. P. Eichenberger, USA

1700. Sears, R. I., Merlet, C. F., and Putland, L. W., Flight determination of drag of normal-shock nose inlets with various cowling profiles at Mach numbers from 0.9 to 1.5, *NACA Rep.* 1281, 19 pp., 1956.

Free-flight tests were made with normal-shock nose-inlet models with NACA 1-series, parabolic, and conic cowling profiles to investigate the external drag characteristics at an angle of attack of 0°. The Mach number range of the tests was from 0.9 to 1.5, the mass-flow ratio was from 0.7 to 1.0, and the Reynolds number based on body maximum diameter varied from 2.5×10^6 to 5.5×10^6. Two related nonducted bodies were also tested for comparison purposes.

At the maximum flow rate the inlet models had about the same external drag at a Mach number of approximately 1.1, but at higher Mach numbers the conic cowling had the least drag. Blunting or beveling the lip of the conic cowling while keeping the fineness ratio constant resulted in a slightly higher drag than for the sharp-lip conic cowling at maximum flow rate, but at a mass-flow rate of 0.8 the blunt-, beveled-, and sharp-lip conic cowlings and the parabolic cowling all had about the same drag. The higher drag of the NACA 1-49-300 cowling compared with the blunt-lip conic cowling is associated with the greater fullness back of the inlet.

From authors' summary

1701. Heaslet, M. A., Bodies with given base area or volume, *NACA TN* 3289, 30 pp., July 1957.

Minimization of wave drag in supersonic flow for thin aerodynamic shapes carrying no lift is studied when either base area or volume is specified. For given base area, general formulas are found that cover, as special cases, quasi-cylindrical bodies of revolution, wings having planforms with fore and aft symmetry, slender bodies, and certain classes of yawed wings. For given volume, minimization of the external wave drag of a ducted body of revolution is achieved in closed analytic form. In two examples, the determination of surface shape corresponding to the minimum drag is carried to completion.

From author's summary by D. W. Holder, England

1702. Schmidt, C. M., and Hanawalt, A. J., Skin temperatures of a satellite, *Jet Propulsion* **27**, 10, 1079–1083, Oct. 1957.

The need for a workable artificial earth satellite has been established both as a reconnaissance vehicle and also as a prerequisite for space travel. One of the attendant problems in the design of such a vehicle is the control and therefore prediction of temperatures that would exist in flight. Previous papers on this topic have brought out many salient features of such predictions but have not been entirely realistic. The present paper attempts to improve on these assumptions and gives numerical computations for a particular configuration that is considered feasible for a satellite design. The example investigated in paper is a nonrotating cylindrical shell with one end pointing earthward. The problem of analysis is largely one of geometry, involving spacewise as well as timewise variations in skin temperature. The skin temperatures that would exist are very dependent on the properties of the surface, particularly emissivity and absorptivity, large values producing the widest range in surface temperatures. By proper choice, if possible, of these parameters, this range can be greatly controlled. In particular, the mean temperature of the satellite skin is primarily a function of α/ϵ. For the specific configuration considered, nominal limits on the skin temperatures are −200 and +400 F. From authors' summary

1703. Gilmore, A. W., and Keller, T. L., Damping due to internal flow, *J. aero. Sci.* **24**, 4, 317–318, Apr. 1957.

Because of the increasingly large mass-flow rates being handled by internal-flow engines as flight speeds are increased (e.g., supersonic ramjets), the question of the contribution of the internal flow to the total aerodynamic damping has become of interest.

Paper derives an expression for the additional damping coefficient due to internal flow based upon considerations of the change in flow angle of the air as it enters the tube and on the Coriolis effect on the fluid within the tube. The relations obtained apply to both straight and curved ducts when the distances are measured in straight lines from the center of rotation. An expression is also presented for the percentage contribution to the total damping from the flow of fuel along the duct length.

From authors' summary

1704. Graham, M. E., Examples of calculation of minimum supersonic drag due to lift by solution of two-dimensional potential problem: elliptical-planform wings and an approximate delta-planform wing, *Douglas Aircr. Co. Rep.* SM-22754, 15 pp., Mar. 1957.

Two examples are presented of the use of two-dimensional potential flow solutions to obtain minimum drag due to lift of three-dimensional planar wings. The method of relating the two-dimensional potential problem to the three-dimensional drag minimization problem for spatial as well as planar wing systems can be developed from combined flow-field concepts. For the first example, the minimum drag of unyawed and yawed elliptical-planform wings is obtained. The drag values agree with Jones'

results. For the second example, the minimum drag of a wing with a planform very nearly that of a sonic-edge delta wing is obtained. The minimum drag value is about 11% less than the drag of a flat wing of the same planform.

From author's summary

1705. Winter, K. G., Tables of characteristics slopes for use in the design of nozzles for supersonic wind tunnels, *Aero. Res. Counc. Lond. curr. Pap.* 337, 5 pp. + 5 tables + 1 fig., 1957.

Tables are given which are of use in calculating characteristic networks appropriate to two-dimensional nozzles for Mach numbers up to 4.5. The tabulated characteristics slopes enable the coordinates of a characteristics intersection each to be evaluated in one operation on a desk calculating machine.

From author's summary

1706. Fraenkel, L. E., Calculations of the pressure distributions and boundary-layer development on a body of revolution with various parabolic after bodies at supersonic speeds, *Aero. Res. Counc. Lond. Rep. Mem.* 2966, 39 pp., 1957.

Detailed calculations are made of the flow over a series of bodies at Mach numbers of 1.2, 1.4 and 1.6 and Reynolds numbers of 48 to 72 millions. The bodies consist of a basic forebody and parallel portion to which are added truncated parabolic afterbodies of three different thickness ratios. The calculations are in three main parts: (1) Calculation of the inviscid flow over the bodies, mainly by the method of characteristics; (2) calculation of the boundary-layer properties by what is essentially an extension to compressible flows of the method of Squire and Young; (3) calculation of the pressure distribution on the "modified" afterbodies which result from adding the displacement thicknesses to the original profiles, by Ferri's method of linearized characteristics.

The results indicate that the slender-body and quasi-cylinder theories predict the flow over afterbodies with only very limited accuracy for the thickness ratios and Mach numbers occurring in practice, but that the linearized similarity law remains a useful means of generalizing the particular results of exact inviscid-flow calculations. The boundary layers are seen to thicken very rapidly toward the rear of the afterbodies and this causes pressure changes of as much as 12% of the peak suction. The skin-friction results agree extremely well with those for the equivalent flat plate.

From author's summary by M. J. Goglia, USA

1707. Beane, B. J., and Ryan, B. M., Supersonic drag calculations for a cylindrical shell wing of semi-circular cross-section combined with a central body of revolution, Douglas Aircr. Co. Rep. SM-22627, 33 pp., Oct. 1956.

Author investigates combination of semi-ring and slender body as a suitable configuration for low drag and high L/D in supersonic flow. The wave drag is not zero as in the complete ring body combination proposed by Ferrari but this is compensated by the reduction in friction drag and improvement in lift characteristics. Calculations are made for a range of values of $2R$ tan μ/c, where R is the radius, c is the chord of the semi-ring, and μ is the incident Mach angle. For each value of this parameter the optimum spanwise loading is determined.

M. Holt, USA

1708. Uchida, S., and Yasuhara, M., On the preliminary experiment of supersonic flow produced by multi-nozzle plate, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956; 277-281.

An experimental investigation on the supersonic flow produced by a multi-nozzle plate is reported. The tests were made in the range of $M = 1.4$ to 2.5, and the area ratios of nozzles necessary for giving any expected Mach number in the test section are determined. Inspecting the uniformity of the flow field, it is found that the maximum deviation of Mach number reaches several percentages of the mean value. It will not only be a suitable device for practical purposes, but also be an appropriate instrument for the grid producing turbulence in supersonic flows. Examples of the schlieren photographs of the testing field and flows around bodies are also shown. From authors' summary

1709. Kogan, M. N., Some properties of spatial supersonic flows (in Russian), *Prikl. Mat. Mekh.* **20,** 5, 661-662, Sept.-Oct. 1956.

Consider steady linearized supersonic flow parallel to the x-axis about a finite body B. Let S be the characteristic surface that separates disturbed from undisturbed flow. Let $u^*(x, z) = \int u(x, y, z)dy$ and $w^*(x, z) = \int w(x, y, z)dy$ integrated over a segment that starts and ends on S, where u, w are x, z velocity components. Author shows that (1) u^*, w^*, and also (2) $(uy)^*$, $(wy)^*$ satisfy equations of linearized plane flow.

Following are typical of five consequences mentioned by author. First, let B be a finite wing W with supersonic leading and trailing edges. Behind W insert a second wing W' bounded by lines parallel to y-axis and by curves on S. Then lift and pitching moment of W' are unaffected by presence of W. Second, consider a wing with antisymmetrically deflected ailerons. Suppose the characteristic surfaces bounding the regions disturbed by the ailerons do not intersect the leading or trailing edges of the wing. Then the rolling moment depends only on the ailerons' shape and their distance from the plane of symmetry.

J. H. Giese, USA

1710. Love, E. S., Aerodynamic investigation of a parabolic body of revolution at Mach number 1.92 and some effects of an annular supersonic jet exhausting from the base, *NACA TN* 3709, 62 pp., Sept. 1956.

An aerodynamic investigation of a parabolic body of revolution was conducted at a Mach number of 1.92 with and without an annular supersonic jet exhausting from the base. Measurements with the jet inoperative were made of lift, drag, pitching moment, radial and longitudinal pressure distributions, and base pressures. With the jet in operation, measurements were made of the pressures over the rear of the body with the primary variables being angle of attack, ratio of jet velocity to free-stream velocity, and ratio of jet pressure to stream pressure.

The results with the jet inoperative showed that the radial pressures over the body varied appreciably from the distribution generally employed in most approximate theories. The linearized solutions for lift, pitching moment, and center of pressure gave relatively poor predictions of the experimental results. An analysis of several theoretical methods for calculating pressure distribution and wave drag showed that some methods gave results in considerable disagreement with experimental values.

Maximum effects of the jet were obtained at the lower ratio of jet velocity to stream velocity and the highest ratio of jet pressure to stream pressure. These effects amounted to a slight decrease in foredrag, a reduction in lift, and a shift of center of pressure in a destabilizing direction.

From author's summary

1711. Fabri, J., and Paulon, J., Theory and practice of supersonic air-to-air injectors (in French), *ONERA NT* 36, 25 pp., Sept. 1956.

Authors present a method of extrapolating classical ejector performance to the case of large supersonic units based on an aerodynamic analysis of the problem, taking into consideration the various geometrical, mechanical, and aerodynamic parameters. Experimental verification of the method is included. Report presents a rather thorough investigation of subject.

G. V. Bull, Canada

1712. Beastall, D., Flow instability of centre-body diffusers at supersonic speeds, *Aero. Res. Counc. Lond. Rep. Mem.* 2933, 12 pp., 1956.

This note offers explanations for certain types of flow instability which occur with center-body diffusers at supersonic speeds. These instabilities manifest themselves as oscillations of the shock pattern ahead of the diffuser and the flow through the diffuser for certain conditions of operation and are likely to affect seriously the performance. Two main types of oscillation have been distinguished: a violent oscillation which occurs when the flow through the diffuser is throttled below a certain value; a less severe oscillation which occurs when the vortex sheet from the intersection of the shock waves ahead of the diffuser or a separated boundary layer strikes the cowl.

The explanations of the oscillations are substantiated by schlieren photographs of two- and three-dimensional model diffuser tests in a wind tunnel. It seems possible, in the light of the explanation given in this note, to be able to predict the range of instability of any center-body diffuser configuration by fairly simple model tests. From author's summary

1713. Brinich, P. F., and Sands, N., Effect of bluntness on transition for a cone and a hollow cylinder at Mach 3.1, *NACA TN* 3979, 42 pp., May 1957.

Bluntness was more effective in displacing transition downstream on a cylinder than on a cone. The downstream displacement of transition is related to the formation of a shock layer within which the Reynolds and Mach numbers are reduced and to pressure gradients that exist over the forward part of the model. Round bluntness in general had a favorable effect, whereas sharp-cornered flat bluntness above a certain size had unfavorable effects on the location of the transition point.

From authors' summary

1714. Erickson, W. D., Study of pressure distributions on simple sharp-nosed models at Mach numbers from 16 to 18 in helium flow, *NACA TN* 4113, 42 pp., Oct. 1957.

Experiments were made in a small helium tunnel at stagnation pressures up to 2800 psi, giving Reynolds numbers up to 1.5×10^6 per inch. Models used were flat plate, 5° and 10° wedges, and 5° and 10° cones. Heat transfer to models was effectively zero. For the flat plate, induced pressures were about half the values found by Hammitt and Bogdonoff [AMR **9**, Rev. 2260] for same values of the hypersonic interaction parameter χ. Author suggests that this discrepancy cannot be due to smaller leading-edge thinkness in present work, since correction given by Cheng and Pallone [*J. aero. Sci.* **23**, p. 700] does not bring results into agreement.

Measured pressures on flat plate are higher than zero-order solution of Lees for strong interaction region, but author shows that finite leading age correction given by Cheng and Pallone accounts for this difference. Reviewer notes that experimental results on flat plate agree fairly well with solution by Lees [AMR **9**, Rev. 3766] allowing for effects of temperature rise and vorticity due to leading edge shock wave.

Measured induced pressures on wedges and cones were lower than values given by second-order solution of Lees and Probstein for weak interaction region. For wedges, author attributes this to three-dimensional flow in boundary layer, but for cones no explanation is given. Agreement with Taylor-Maccoll theory for cones improves with increasing cone angle.

W. A. Mair, England

Wave Motion in Fluids

(See Revs. 1518, 1747)

Turbulence, Boundary Layer, etc.

(See also Revs. 1623, 1677, 1690, 1713, 1714, 1723, 1724, 1782, 1787, 1791, 1810, 1816)

1715. Hansen, A. G., Possible similarity solutions of the laminar, incompressible, boundary-layer equations, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-79, 7 pp.

The writer presents general equations of motion of an incompressible laminar flow in the boundary layer in three-dimensional orthogonal coordinate system. The classical boundary conditions in two directions are used. A similarity variable (more or less in the classical sense of Prandtl) is assumed, thus enabling one to introduce the functions of it and to reduce the partial equations to ordinary. The condition that the coefficients in the equations be equal (thus reducing the system to that of ordinary equations) furnishes a set of requirements for the proportionality of these coefficients and for the similarity solutions. A few special cases are discussed and the results are presented by means of a table containing the specific forms of the transformation functions which must be used in the similarity solutions in question.

The writer concludes that : a general analysis for all possible types of similarity solutions has not yet been evolved; little work has been done in solving "similar" ordinary differential equations of the boundary layer; further work might be carried out on the differential geometric properties of surfaces and coordinate systems associated with similarity analysis.

M. Z. v. Krzywoblocki, USA

1716. Potter, O. E., Laminar boundary layers at the interface of co-current parallel streams, *Quart. J. Mech. appl. Math.* **10**, 3, 302-311, Aug. 1957.

Author obtains solution for laminar mixing of two co-current, parallel, two-dimensional, incompressible flows in terms of velocity ratio and ratio of products of density and dynamic viscosity for a sextic polynomial velocity distribution in the mixing zone. Numerical results are presented for a velocity ratio of 10 and product ratios of 0.01 to 100 and for a velocity ratio of 0.501 and a product ratio of 1.

Comparison of interfacial velocity and shear stress with exact solution of Lock [AMR **4**, Rev. 3642] shows maximum differences of 2%. Comparison with results using a quartic distribution indicates general superiority of sextic distribution (except for shear stress at large product ratios), although differences are again less than 1%. Interfacial stability problem and assumption of zero streamwise pressure gradient limit solution to mixing of infinite flows at very low Reynolds numbers.

H. E. Brandmaier, USA

1717. Stewartson, K., On almost rigid rotations, *J. Fluid Mech.* **3**, 1, 17-26, Oct. 1957.

In an extremely interesting paper, author studies flow between two coaxial rotating disks, when each has a small angular velocity (which is a function of radius) superimposed on a constant angular velocity, the latter being the same for the two disks. Of particular interest are results obtained when there is a discontinuity in the angular velocity of either disk, for then the flow has some bearing on earlier work by Proudman [AMR **10**, Rev. 4061] on shear layers in rotating fluids.

Author's work suggests that, in the region of the radius of discontinuity, a cylindrical shear layer is formed in the fluid, this being additional to the boundary layers which are present on the disk surfaces. If the angular velocity of the main body of fluid is continuous, which is the case if the flow is antisymmetrical about the plane midway between the disks, the cylindrical shear layer transfers fluid from the boundary layer of one disk to the boundary layer of the other; its thickness is $O(\nu^{1/4})$, where ν is the kinematic viscosity. On the other hand, if the angular velocity of the main

body of fluid is discontinuous, which is the case if the flow is symmetrical about the plane midway between the disks, the angular velocity change takes place in a layer of thickness $O(\nu^{1/4})$. An additional feature of this case is that fluid flows parallel to the axis (of rotation) within the layer of thickness $O(\nu^{1/4})$, and "returns" within a superimposed shear layer, of thickness $O(\nu^{1/3})$, which is embedded in the main shear layer of thickness $O(\nu^{1/4})$.

Reviewer has noticed several typographical errors in the paper, for example in formulas (3.2), (3.3), (3.7), and (3.9).

J. T. Stuart, England

1718. Napolitano, L. G., Axially symmetric motion of a non-uniform gas mixture (in Italian), *Aerotecnica* **37**, 3, 129–132, June 1957.

From basic relations due to S. Chapman and T. G. Cowling [AMR **7** (1954), Rev. 2592], explicit forms of the diffusion equation, the continuity equation, the equation of motion, and of the energy equation for the flow of a mixture of two ideal gases in a system of general curvilinear orthogonal coordinates are derived, the inertia terms being omitted in the equation of motion. The application of general results to axially symmetric motions can be simplified considerably if Prandtl's boundary-layer-theory conditions are accepted and if some additional assumptions concerning the geometry of a certain surface of revolution are made. Two forms of equations are obtained, depending on whether the effects of the transversal curvature of the surface are taken into account in the first approximation or if some additional members are necessary. Mangler's transformation, which enables to establish a correspondence between the theory of plane and axisymmetric viscous flows, can be extended without difficulties to flows of nonuniform gas mixtures.

A. Kuhelj, Yugoslavia

1719. Batchelor, G. K., Diffusion in free turbulent shear flows, *J. Fluid Mech.* **3**, 1, 67–80, Oct. 1957.

Paper concerns some statistical properties of the displacement of a marked fluid particle released from a given position in a turbulent shear flow and in particular with the dispersion about the mean position after a long time. These shear flows have a similar structure and it is assumed that the velocity of a prescribed fluid particle exhibits a corresponding Lagrangian similarity enabling it to be reduced to a stationary random function.

Author is then enabled to find the dispersion of the particle about its mean position and the dependence of its maximum mean concentration on time for plane jets and wakes, round jets and wakes, and for mixing layers. For example, he shows that the dispersion in the longitudinal direction is proportional to the thickness of the shear layer at the mean position of the particle.

K. Stewartson, England

1720. Zikunova, A. M., The correlational, structural and spectral functions of interstellar turbulence (in Russian), Byul. nauk. stud. Konferentsii, 1954; L'viv, Vid-vo un-ta, no. 2, 78–80, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6012.

Graphs are given for the correlational, structural and spectral functions of interstellar turbulence. The methods of calculation of these functions and the connected results are given in the work of the abstractor [*Astronom. Zh.* **32**, no. 3, p. 255, 1955].

S. A. Kaplan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1721. Stratford, B. S., Turbulent diffuser flow, *Aero. Res. Counc. Lond. curr. Pap.* 307, 55 pp. +9 figs., 1956.

On the basis of the standard mixing-length theory, author deals with pure radial flow, first in two dimensions and then in three. He assumes the mixing length to be proportional to the radial distance from the apex of the flow, since the mixing length in a straight pipe is accepted to be proportional to the pipe width or diameter. This permits a complete solution for the time-mean motion which is applied to two-dimensional and axisymmetric cone diffusers. The solution is restricted to the region in which the velocity profile has attained a constant shape.

The velocity profile is expressed in terms of mixing-length distribution, and the normal gradient of velocity at the wall at separation is found to be infinite, despite the wall shear stress being zero. Another interesting result is a relationship between the mixing-length distribution and the critical diffuser angle required for the onset of separation. This angle is found to be proportional to the square of the turbulence level, and the turbulence level for critical flow in a 10° circular cone is found to be 30% higher than for the flow in a straight pipe.

The results are applied to wide-angle diffusers with side jets or central wakes. Author suggests on the basis of his analysis that a central wake could be used for preventing flow separation in wide-angle diffusers. For a side jet to persist a long distance downstream, its velocity at any axial station must exceed twice the mean velocity at that station, and the power required is about 40% of the power in the main part of the flow if the profile is fully developed at entry. Author finds that the errors involved in the use of the usual simple form of the turbulent shear stress as compared with a more general form are small.

A. H. Sacks, USA

1722. Kampe de Feriet, J., The concept of averages in the theory of turbulence (in French), *R. C. Semin. mat. fis. Milano* **27**, 43 pp., 1955–1956.

Highly mathematical discussion of the question: How can one define the average value of a function in such a way that Reynolds turbulence equations follow rigorously from the Navier-Stokes equations? Author gives necessary and sufficient conditions for this definition and shows that his definition differs necessarily from the usual, inadequate ones. Discussion is based on theory of measure and makes abundant use of earlier work by the author.

D. ter Haar, England

Aerodynamics of Flight; Wind Forces

(See also Revs. 1456, 1489, 1509, 1683, 1686, 1701, 1709, 1734, 1836)

1723. Pratt, K. G., and Bennett, F. V., Charts for estimating the effects of short-period stability characteristics on airplane vertical-acceleration and pitch-angle response in continuous atmospheric turbulence, *NACA TN* 3992, 61 pp., June 1957.

Charts are presented for estimating the effects of variations in short-period stability characteristics of a rigid airplane on its root-mean-square vertical-acceleration and pitch-angle response to continuous atmospheric turbulence. The charts are best suited for application to rigid unswept-wing airplanes of not more than 200-ft wing span flying at low subsonic speeds. Analysis of the charts indicates that the variations of the vertical acceleration and pitch angle with the other parameters are largely determined by the damping ratio of the airplane and a relative-turbulence scale. Examples show that the vertical-acceleration response of a moderate-speed unswept-wing fighter airplane is increased by a rearward shift in the center of gravity, is not changed significantly with a change in altitude if the equivalent airspeed and true turbulence intensities are constant (effects of changes in Mach number are not included), and is increased by an increase in the geometric scale.

Y. C. Fung, USA

1724. Laitone, E. V., Real part of the square root of a complex number, *J. aero. Sci.* **24**, 5, 391–392, May 1957.

An alternating power series expansion for the real part of the square root of a complex number is given. Result is applied to

evaluation of stability requirements for a rolling missile. A simple expansion for the upper bound of the real part is obtained giving adequate design criteria, especially for missiles having a moderately large negative C_{m_α}. Article is a comment on works by R. E. Bolz [AMR **7**, Rev. 1575] and A. E. Bryson [AMR **6**, Rev. 2941]. K. Flodin, Sweden

1725. Diederich, F. W., and Drischler, J. A., Effect of spanwise variations in gust intensity on the lift due to atmospheric turbulence, *NACA TN* 3920, 25 pp. + 6 tables + 8 figs., Apr. 1957.

A statistical procedure for analyzing the gust load problem, [AMR **10** (1957), Rev. 4110], is applied to calculate the effect of atmospheric turbulence on the lift. Previous work is extended by considering effects of longitudinal component of turbulence. Turbulence is assumed to be stationary, homogeneous, and isotropic. Results of calculations of the lift spectra and correlation functions for several spanwise weighting functions and various atmospheric spectra are presented. It is found that the mean-square gust intensity experienced by the wing is decreased by spanwise variations of the gust intensity.

L. Landweber, USA

1726. Preston, J. H., Note on the circulation in circuits which cut the streamlines in the wake of an aerofoil at right-angles, *Aero. Res. Counc. Lond. Rep. Mem.* 2957, 8 pp., 1956.

Wake of an airfoil is taken to be a jet issuing from the trailing edge. Curvature of jet causes a pressure difference, hence a difference in tangential speed in the main flow at both sides. An expression for the resulting circulation in circuits cutting the jet twice is derived. L. J. F. Broer, Holland

1727. Kerr, T. H., A new standard for the prediction of full-scale spin and recovery characteristics from model tests, *AGARD Rep.* 25, 21 pp., Feb. 1956.

The original simple standard for the prediction of full-scale aircraft spin and recovery characteristics for model tests has been proven unsatisfactory for modern aircraft. Based upon a wealth of experience with spin and upon specific model-to-full-scale comparisons, author presents an empirical method of allowing for scale effect by taking into account the influence of thickness/chord ratio of the wing, the dimensionless spin rate (λ), and the moment of inertia ratio B/A of the aircraft. A new standard for the prediction of full-scale spin and recovery based upon simple tunnel techniques and using the above parameters is given along with a predicted accuracy of ± 3 units ($10^1 C_n'$) for $-1.0 < (1 - B/A) < +0.5$. R. E. Bolz, USA

1728. Doetsch, K. H., The time vector method for stability investigations Part I. Basic information. Part II. Longitudinal motion, *Aero. Res. Counc. Lond. Rep. Mem.* 2945, 36 pp., 1957.

1729. Jones, J. P., Helicopter rotor blade flapping and bending—The determination of the higher harmonics of rotor blade flapping and bending. I. Rigid blade motion. II. Elastic blades, *Aircr. Engng.* **24,** 338, 64–66, Mar. 1957; **24,** 339, 107–112, Apr. 1957.

Harmonics of helicopter rotor flapping are determined in part I for a rigid blade of constant chord, neglecting reverse flow, tip stalling, and tip loss. Instead of expressing blade flapping angle as a trigonometric series in blade angular position and solving for constant coefficients, an expansion in powers of the tip-speed ratio is assumed with coefficients which are functions of blade position. Problem of solving simultaneous equations for the unknown constant coefficients is replaced by successive, but not simultaneous, differential equations.

Application in part II to elastic blades assumes deflection at a spanwise station given as a sum of normal vibration modes times unknown functions of time. Lagrange's equation leads to simultaneous differential equations which are solved for flapping angle and mode shapes by again assuming series expansions in powers of tip-speed ratio and variable coefficients; determination of coefficients is made from successive sets of differential equations.

Series expansion seems valid for normal ranges, but complete analysis is not given. Comparison of this theory, and others, with experimental results is not satisfactory, indicating that rotor blade dynamics merits much more serious theoretical and experimental attention. E. T. Welmers, USA

1730. Lang, D. A., Some advantages and disadvantages of variable and non-linear gearing between the pilot's control and the control surface, *Aero. Res. Counc. Lond. curr. Pap.* 263, 15 pp. + 12 figs., 1956.

1731. Cicala, P., Discontinuous solution of the problem of optimum flight (in Italian), *Atti Accad. Sci. Torino Cl. Fis. Mat.* **90,** 533–551, 1955–1956.

1732. Tye, W., Philosophy of airworthiness, *AGARD Publication, Rep.* 58, 14 pp. + 3 appendixes + iv, Aug. 1956.

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 1448, 1509)

1733. Lehrian, Doris E., Calculation of stability derivatives for oscillating wings, *Aero. Res. Counc. Lond. Rep. Mem.* 2922, 23 pp., 1956.

Paper is based on a development of the modified vortex-lattice method [Jones, *Aero. Res. Counc. Lond. Rep. Mem.* 2470]. Jones' method is adapted for low values of the frequency parameter ω by assuming that the lift distribution is the sum of simple functions, the corresponding doublet distributions being expressible as polynomials in ω. Only first-order terms in ω are retained.

Aerodynamic derivatives are obtained for delta and arrowhead wings and circular plates for vertical translation and pitching oscillations. Satisfactory agreement is obtained with experiment and with values calculated by the Multhopp-Garner method [Garner, *Aero. Res. Counc. Lond. Rep. Mem.* 2885].

The corresponding derivatives are calculated for compressible flow by using similarity rules. There is some discrepancy between the theoretical and experimental results. It is shown that the effect of the similarity rule is to magnify possible inaccuracies occurring in the incompressible solution. In comparing results, no account is taken of effect of thickness, boundary layer, or wind-tunnel interference.

A. W. Babister, Scotland

1734. Goukroger, D. R., Wind-tunnel flutter tests on a delta wing with an all-moving tip control surface, *Aero. Res. Counc. Lond. Rep. Mem.* 2978, 17 pp., 1956.

Wind-tunnel tests on a half-span model delta wing, fitted with an all-moving tip control surface, are described. The model, which is flexible, has a leading-edge sweepback of 45°; and the control surface, which is rigid, has an area 9.3% of the gross wing area. The control surface is hinged at 47.4% of its root chord. Provision is made for varying the circuit stiffness and the position of the center of gravity of the control surface and its pitching moment of inertia.

The tests show that certain combinations of control-surface inertia and circuit stiffness produce very low flutter speeds. The effect of reducing the control-surface area by cropping the tip is examined, and in general is found to be beneficial. It is shown that the most favorable conditions for avoiding low flutter speeds exist when the control-surface center of gravity is well forward of

the hinge-line and the control-surface natural frequency is well removed from the natural frequency of the wing in its fundamental flexural mode. From author's summary

1735. Templeton, H., Flutter research at the Royal Aircraft Establishment, Farnborough, *AGARD Publications, Rep.* 4, 32 pp. + iv, Sept. 1955.

Report outlines the basic objective and the main activities of flutter research at the R. A. E. Some examples of these activities are described. From author's summary

1736. Niblett, L. T., Flutter calculations on a rudder with trailing-edge spoiler, *Aero. Res. Counc. Lond. curr. Pap.* 277, 8 pp. +4 figs., 1956.

Flutter calculations made on a rudder with trailing-edge spoilers are described. The results obtained agree with the flight experience which has been acquired so far (except for the frequency of the flutter) in spite of the simplicity of the aerodynamic assumptions. It has been found that, as with tab flutter, a form of flutter involving the main surface (fin) occurs with an over-mass-balanced spoiler. From author's summary

1737. Aerodynamic stability of suspension bridges, *Trans. Amer. Soc. civ. Engrs.* **120,** 721–781, 1955.

Thorough discussion is presented of aerodynamic forces, their resonance, amplitude of oscillations, the motion of the bridge and other individual factors affecting the stability of suspension bridges. Following conclusions are made: (1) Sections stiffened with trusses are more favorable than girder-stiffened sections. (2) Deck slots and other devices reduce dangerous wind action. (3) Lateral four-sided truss systems increase the frequency of torsional motion, inhibit flutter and raise critical velocity of torsional motion and should not be used. (4) Cases are discussed in which high natural frequency of vibration is favorable. (5) Effects of bridge sites on serious oscillations and objectionable amplitudes are considered. (6) Increased weight and stiffness of the bridge have beneficial effect on structural damping and safety. Suggestions are made on how to attain high degree of security against aerodynamic forces, especially by properly modified design.

The subject is presented in the following chapters: Wind pressure. Natural vibrations and their factors. General behavior of bridges in the wind. Values of theories of: negative slope, vortex, flutter. Energy and damping. Model testing. Bridge performance. Design criteria and methods: means available to the designer, avoiding sources of excitation and resonance, increasing damping capacity, wind exposure probability. Summary of criteria and additional research required.

J. J. Polivka, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 1491, 1612, 1631, 1664, 1667, 1668, 1677, 1702, 1768, 1770, 1771, 1773, 1786, 1801, 1802, 1813, 1817)

Book—1738. Shchapov, N. M., Turbines of water power plants (in Russian), 2nd ed., Moscow, Gosenergoizdat, 1955, 275 pp.

A carefully elaborated and edited handbook on the mechanical equipment of hydraulic power plants, based on a wide experience in Russia. Contents: Turbomachines, their work and characteristics. Turbine similarity laws. Impulse turbines. Reaction turbines, casing, draft tubes. Cavitation. Radial-axial turbines. Propeller turbines. Model tests, diagrams. Losses in turbines and their energy balance. Standards and selection. Automatic regulation. Temporary irregularities in operation. Tide turbines. Storage and pumping. Stream turbines. Turbine manufacturing. Operation and maintenance. Field tests of turbines.

An extensive bibliography of 206 titles exclusively in Russian, is added, although European and American machines and methods are discussed in the book. Russian progress in water power development is reflected in this valuable book.

S. Kolupaila, USA

1739. Benedict, R. P., and Meyer, C. A., Electrolytic tank analog for studying fluid flow fields within turbomachinery, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-120, 22 pp.

A method is described for obtaining, by an electrolytic analog, the flow streamlines and velocity components throughout the fluid-flow field of a stream turbine. Following a brief historical review of the work pertinent to this study, equations are developed which describe the electric field within an electrolyte and the fluid field within a turbine. Electrical circuits are presented. Mechanical features are reviewed. Construction of analog models is described. R. C. Binder, USA

1740. Stone, A., Effects of stage characteristics and matching on axial-flow-compressor performance, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-139, 17 pp.

Factors affecting axial-flow-compressor performance are described in general terms. Emphasis is placed on stage characteristics and methods of varying these to give over-all improvements, especially in relation to surge.

Specialists will find little of interest, but paper is a useful introduction for persons new to field. F. G. Blight, Australia

1741. Fabri, J., and Siestranck, R., Rotating stall in axial flow compressors, *J. aero. Sci.* **24,** 11, 805–812, Nov. 1957.

A representative circular section of a moving blade row is developed as a plane cascade translating uniformly along its front (y – axis). Absolute fluid (incompressible, nonviscous) entry velocity is assumed to be parallel to x – axis, i.e., normal far upstream to the cascade, which is further considered as an actuator straight line (y – axis). In a reference system moving with the translating stalled zones, the fluid motion is stationary. Upstream of the actuator line, the flow field results from the superposition of the asymptotic uniform entry velocity and a harmonic perturbation velocity field (u, v). Downstream flow is rotational because of the stalled zones, and authors introduce (a) an "asymptotic" rotational perturbation velocity ($\bar{u}, \bar{v}$) which is assumed to be constant along each linearized streamline, and (b) a harmonic perturbation velocity field (u', v') which vanishes at downstream infinity (as does u, v at upstream infinity).

On the actuator line (y – axis) the perturbation velocity components (subscript 0) are related by the continuity equation and the relative cascade exit angle condition, yielding a correspondence relation between u_0, u_0' and v_0', from which a second conjugate relation follows between v_0, u_0'' and v_0'', as shown in an appendix. Further, Bernouilli equation written in the relative system and in that resting relative to the stalled zones (third term of Eq. (5′) and second term of Eq. (6) should read with U and U^2 instead of V and V^2, respectively) yields with the previous relations two linear discontinuous conditions between u_0 and v_0, valid for the unstalled and stalled regions, respectively. Determination of the upstream perturbation flow field (u, v) satisfying both conditions on its boundary $x = 0$ is demonstrated in a second appendix by means of a simple conformal transformation. Finally, expressing the flow conditions at both ends of the stalled zones and calculating the stalled cascade pressure rise gives a simple formula for the stall propagation velocity. No definite performance curve needs to be specified for the stalled cascade part, only a discontinuity between both operating conditions is actually assumed. An example of a calculated flow field is given and some indications are presented for an extension of the simplified linearized theory to a nonlinearized rotating stall

representation yielding the same formula for the stall propagation velocity, as well as a formula for the extent of the stalled zones.

Theory is found to be in good agreement with experimental results obtained on two isolated rotating blade rows. It necessitates very few assumptions on the behavior of the stalled blade channels and it is, therefore, a very interesting contribution to the study of this complex phenomenon. P. Schwaar, France

1742. Yablonik, R. M., Influence of the aerodynamic wake on flow about cascades of turbine profiles (in Russian), *Trudi. Bezbitsk. in-ta transp. mashinostr.* no. 15, 22-30, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5118.

Experimental investigation of the structure of a flow behind the individual stationary cascades of turbine profiles includes the joint testing of two successively disposed stationary turbine cascades (guide and working). The tests were made at small Mach numbers of the air flow, approximately equal to 0.2.

It was shown that the coefficient of nonhomogeneous flow rapidly decreases with distance from the cascade, whereas the coefficient of energy loss increases; these values become stabilized at a relative distance behind the lattice $z/b = 0.2$-0.25 (where z is the distance from the cascade and b the chord of the profile). The nonhomogeneous flow behind the cascade increases considerably at positive angles of attack and remains practically unchanged at negative angles of attack.

Joint investigation of two cascades was performed with a varying disposition of the working cascade relative to the edge wake at exit from the guide cascade. It was shown that the variations in the stress on the working blade which occur during this depend on the axial gap between the cascades and the angle of attack of the flow impinging on the working cascade. Thus for example, with an increase of the relative axial gap δ/b_1 (δ is the distance between cascades, b_1 the profile chord of the guide cascade) of between 0.05 and 0.2, the relative variation of fluctuation of the peripheral stress is reduced from 10 - 14 to 6 - 8% and amounts to ~4% at $\delta/b_1 = 0.4$. Thus the increase of the axial gap between the cascades leads to a considerable reduction of the stress oscillations which act on the working blades.

V. Kh. Abiants
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1743. Shorstyuk, A. N., The determination of the stability limits of the performance of ventilators, pumps and compressors (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **21**, 195-202, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5859.

Limits of stability have been determined for the work of ventilators and pumps, connected up in various circuits, in cases of a small degree of compression; four types have been investigated, as being of practical interest. The conditions of joint work of compressor and circuit with but little disturbance were investigated; the limits of stability were also determined with small disturbance arising and a large degree of compression.

G. L. Grodzovskii
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1744. Larrowe, V. L., Spencer, M. M., and Tribus, M., A dynamic performance computer for gas-turbine engines, *Trans. ASME* **79**, 7, 1707-1714, Oct. 1957.

Standard analog computing equipment is combined with electromechanical "map readers" made from modified X-Y plotters to form a gas-turbine-engine performance computer. The complete engine computer assembly is composed of a number of smaller assemblies, each of which represents a separate element of the engine.

From authors' summary by Robert M. Stewart, USA

1745. Bryce, W. W., Independence of helicopter rotor derivative under non-uniformity of induced velocity distribution at low forward speed, *Coll. Aero. Cranfield Rep.* 110, 40 pp. + 19 fig., Nov. 1956.

The nonuniform induced velocity distribution, which is used for the hovering case, is a quadratic function of the distance to the rotor axis, which approximates the results of flight measurements very well. For the case of forward speed, an induced velocity distribution, varying linearly from the front to the rear of the rotor disk, is superimposed to the distribution for hovering. The magnitude of the linear distribution depends upon the advance ratio μ, in such a way that for $\mu > 0.14$ the velocity at the front point of the rotor disk vanishes. There is no region of upward velocity as in Mangler and Squire's [AMR **7**, Rev. 2249] distribution.

Values of the drag and side-force coefficients, the flapping coefficients and the rotor derivatives have been calculated for $\mu = 0 - 0.14$. Results have been compared with those obtained when using a uniform induced velocity distribution. The differences are slight except for z_q which, however, is itself very small. For higher values of μ, the effect of the nonuniform distribution might be more significant. In this region, only the flapping coefficients have been calculated, namely up to $\mu = 0.24$. Results here differ from those obtained for the uniform distribution, but are in agreement with flight measurements and with results obtained from Mangler's distribution. The latter involve more complicated expressions than those used by author.

A. I. van de Vooren, Holland

1746. Orlin, A. S., Kruglov, M. G., and Mizernyak, G. N., Methods of gas-exchange investigation in two-stroke engines (in Russian), Internal Combustion Engines, Moscow, Mashgiz, 1955, 31-39; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7392.

Methods and equipment are described for determining the scavenging and filling efficiency of the cylinder of a two-stroke internal-combustion engine by means of gas-sample analysis and indicator diagrams, as used by the "Internal Combustion Engines" chair of the Moscow Higher Technical College.

M. A. Peshkin
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Flow and Flight Test Techniques

(See also Revs. 1542, 1684, 1700, 1705, 1727, 1734, 1771)

1747. Martin, R. J., and Moseley, D. S., Analysis of the effect of pulsations on the response of mercurial-type differential-pressure recorders, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-82, 6 pp.

Oscillations in gas pipelines may cause oscillations of the recording pens of orifice meters, making gas-flow readings difficult. Authors present usual case of a mercury manometer with two gas chambers and two lead lines. The disturbances are superposed to the normal drop in pressure caused by the orifice. Perturbations are assumed harmonic, and acoustic in reference to basic pressure in pipe. Compression waves propagate in both directions in the lead lines, between taps and mercury surfaces. Acoustic waves in the lead lines were assumed plane. Pressure variations in gas chambers may be assumed adiabatic, in the absence of acoustic disturbances. As mercury chambers were small with respect to acoustic wave lengths involved in problem, they were treated as lumped elements. Pressure cycles in gas drive mercury column. Other forces determining motion are: gravity, reactive force on mercury due to accelerating float and pen, and resistance to mercury flow. Gravity, buoyancy, velocity damping between float and mercury and motion of mercury in float chamber determine motion of float. Pen motion is assumed to be determined by proportional

frictionless linkage between float and pen. System of equations developed for pen motion was linearized. Damping was determined by test. Float resistance in mercury was determined by Stokes' law.

Numerical analysis showed three resonance infinite peaks for undamped system, due to resonance of mercury column, resonance of float with respect to mercury, and resonance of lead lines. Damped system showed no infinite peaks. Peak due to resonance of mercury was eliminated; float resonance peak was still high, but finite and lead line resonance peak was low but not negligible. The second peak can be shifted beyond range of normal frequencies by decreasing float mass. A. Balloffet, USA

1748. Hochreiter, H. M., Dimensionless correlation of coefficients of turbine-type flowmeters, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-63, 4 pp.

Paper reports tests on low friction turbine-type flowmeters with hydrocarbons of a wide range of viscosity. For a given meter, tests are correlated by plotting a flow coefficient C (mass flow rate/meter $RPS \times$ duct diameter^3) against a modified Reynolds number (based on duct diameter, blade tip speed, and blade-to-duct-diameter ratio). As might be expected, this gives satisfactory correlation for all fluids tested except when bearing friction becomes important.

Effect of changes in flowmeter dimensions and number of blades on flow coefficient C is also investigated.

E. G. Chilton, USA

1749. Ganush, B., Transmission of a pressure signal by a pneumatic pipeline, *Automation and remote Control (USSR)* **17,** 8, 773-781, Aug. 1956 (Consultants Bureau Translation *Avtomatika i Telekhanika* **17,** 8, 699-707).

A theory is presented for the calculation of the distortion of pressure variations which occurs by transmission through a tube toward a measuring instrument with a certain volume. Results for oscillatory variations are presented in diagrams. Theory contains approximation that the velocity is constant over cross section of the tube. Author states that this assumption will be the cause of discrepancies between his theory and experiments, but he does not remove the assumption. He apparently is unaware of the much more complete paper by Iberall on this subject [AMR **4,** Rev. 1230]

A. I. van de Vooren, Holland

1750. Kimakcyan, A. M., The possibility of error when using automatic apparatus for measuring flow velocities (in Russian), *Trudl. Gos. gidrolog. in-ta* no. 47, 38-40, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6095.

During the automatic registration of the readings of an anemometer or hydrometric wind-vane one gets an error in the recording of the number of revolutions on account of the arbitrarily situated rotor at the moment of "make and break" of contact with the clock mechanism, and also because of the pressure on the rotor of the contact mechanism. An estimate is put forward for the contact pressure by means of a special coefficient for the apparatus, greater than 1, and a determination is made of the possible number of cases of error in the automatic counting of the number of revolutions of the wind-vane. This study is supplementary to the previous deductions of the author. [See *Tr. Gos. gidrolicheskogo in-ta*, no. 90, p. 36, 1952].

N. A. Gretsov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1751. Hays, G. E., A color schlieren system for high-speed photography, *J. Soc. Mot. Pict. Telev. Engrs.* **66,** 6, 355-356, June 1957.

The present paper adds another to the several methods which have been used to obtain color schlieren, namely the purposeful use of longitudinal chromatic aberration in the field lens system. The particular application to high-speed photography makes use of the iris behind the camera lens as the knife edge, with a result that is a combination of a true schlieren effect for the particular color at the knife with a shading effect for the other colors. The latter is precisely what one wishes to avoid in black and white schlieren because it obscures the interpretation. In the present arrangement, however, refraction of light in the working section produces a color-mixing effect which evidently can be monitored to give limited quantitative information on the density-gradient distribution. The author reports good results in his use of the method. Reviewer's personal preference, however, would be for one of the techniques in which the color variations on the screen or film are associated with an exclusively schlieren-type phenomenon, such as the lateral motion of a source image spectrum past a slit, or of a white light image over colored film strips.

D. Bershader, USA

1752. Fisher, M. A., Katz, S., Lieberman, A., and Alexander, N. E., The aerosoloscope: an instrument for automatic counting and sizing of aerosol particles, Proc. Third Nat. Air Pollution Symp., Apr. 1955, 112-119.

Design, development, and construction of an instrument for sizing and counting of aerosol particles. Previous work of other investigators is described. Present instrument is designed for particles of size range of 1 to 60 microns. Manner of operation is as follows: (1) A sample of the aerosol flows into the instrument at a rate of 1.8 liters per min. (2) Provision is made for diluting the aerosol to permit electronic counting of individual particles at a rate of 2000 particles per min. (3) Particles pass through illuminated region, with each particle generating a pulse of scattered light during its transit. (4) The light scattered is received on a photomultiplier, giving rise to an electrical pulse whose amplitude is a function of the size of the particle. (5) The electrical pulses are amplified and then amplitude-sorted in 12 channels. (6) The "aerosoloscope" has built-in provisions for monitoring air-flow rates, electrical calibration and standardization, timing of samples, and other necessary controls. Photograph of instrument, schematic of optical system and of electrical system, comparison charts of particles counted by other methods and by the aerosoloscope are included.

K. J. De Juhasz, Germany

1753. Dosanjh, D. S., Interaction of grids with traveling shock waves, *NACA TN* 3680, 80 pp., Sept. 1956.

Some very interesting data are presented on the collision of a shock wave with a grid (regularly drilled, 1/4-in. thick plate of open-to-total area of 0.75, using 1/4- or 1/2-in. diam holes). Two wave systems are possible. If the flow is subsonic on either side of the grid, then a reflected shock wave and a transmitted shock wave followed by a contact surface result. If the flow is choked at the grid so that the flow immediately downstream is supersonic, then a second shock wave is generated. Consequently, the contact surface now separates two shock waves that face in opposite directions and move downstream.

The work was done in a 4-in. $\times$ 6-in. shock tube. Use was made of the shadowgraph method and a hot-wire anemometer apparatus to study the flow.

Author points out that, up to the time of writing, an analytical solution to this problem did not exist. That is, given a screen or grid of known open-to-total area, an incident shock wave of given strength, and the gas into which it is travelling, can one predict the strengths of the shock waves and the various thermodynamic states in the two wave systems indicated above? Reviewer would like to note that this has now been done quite successfully using a simplified one-dimensional analysis which has been substantiated by an interferometric and wave-speed study of this type of flow. The details are given in the following references: (1)

Franks, W. J. and Hall, J. G., Collision of plane shock waves with wire screens, *J. aero. Sci* **24**, 12, p. 917, Dec. 1957; (2) Franks, W. J., Interaction of a shock wave with a wire screen, *UTIA Technical Note* 13, 1957.

In addition, author reports on qualitative results obtained from the interaction of a shock wave with the turbulent flow emanating from the grid. Reviewer regrets the misleading definition of the pressure drop (Eq. 1) as, "The energy change through the screen"; what actually occurs across the screen is a momentum change.

I. I. Glass, Canada

1754. Graham, M. E., and Bleviss, Z. O., Slender-body calculations of local lift on some non-axially symmetric bodies with application to wind tunnel half models, Douglas Aircr. Co., Rep. SM-22771, 29 pp., Apr. 1957.

Practical problem considered is prediction of lift on nose of fuselage in either subsonic or supersonic flow by use of half models in wind tunnel. In usual tests model is mounted on shim to avoid influence of wall boundary layer. The combination is represented first by bodies of a special cross section with a flat center region which are investigated by means of an electrical analog and second by bodies with elliptical cross sections which are studied analytically. Results indicate that for fuselage of circular cross section the half-body lift may be less than half the lift of the full body. For example, if the final radius of the half-body is equal to the shim thickness, the deviation is 30%. Authors note that a comparison with experimental results indicates that this deviation may be too large.

W. D. Baines, Canada

1755. Hiraki, I., Shinohara, T., and Hashizume, H., An experimental investigation of transonic wind-tunnel test section, II. Tests of perforated walls (in Japanese), *J. mech. Lab. Tokyo* **11**, 5, 153–161, 1957.

Report is presented on the performance of a vacuum-driven transonic wind tunnel with 20 × 25-cm test section having perforated walls of 20% opening ratio at the top and the bottom. Acceptable uniformity of flow was obtained through the Mach number range from 0.7 to 1.3 at 10'–20' wall divergence angle. Shock reflection characteristics at the perforated walls were also investigated at various wall divergence angles. Experimental results obtained in the wind tunnel are reported on the position of the bow shock ahead of a double wedge airfoil with 6° apex angle and on force test of NACA 64A-006 airfoil by use of side-wall balance.

R. Kawamura, Japan

1756. Berndt, S. B., Theoretical aspects of the calibration of transonic test sections, *Flygtekn. Förs̈ksanst. Medd.* no. 74, 28 pp., 1957.

Consideration is given to boundary conditions for partially open and closed channels appropriate for near sonic flow simulation. Application of transonic simularity concepts indicates slot arrangements suitable for groups of models. Slender models prove to require shorter lengths for comparable interference and maximum cross-sectional areas vary with the 4th power of the thickness ratio as opposed to the generally accepted channel area criterion.

J. R. Baron, USA

1757. AGARD papers presented at the seventh meeting of the wind tunnel and model testing panel, Ottawa, Canada, June, 1955, North Atlantic Treaty Organization, 13 papers, 331 pages.

Volume presents a well-balanced series of papers covering model simulation problems, boundary-layer and heat-transfer techniques, and aircraft-icing studies. Slight amount of repetition between some of the papers is not serious. Papers are reviewed in order of appearance in volume.

The representation of engine airflow in wind tunnel model testing, **J. Seddon and L. F. Nicholson:** Authors review general problem of representation of engine airflow in model testing, noting the increased significance of this problem in the supersonic flight case where, at Mach 2, the cross-sectional area of the stream tube in the undisturbed flow corresponding to the air passing through the engines is as high as 16% of aircraft frontal area. Discussion of problem treats intake simulation, jet temperature simulation (cold versus hot jets), internal flow and exit simulation. Many interesting results from R.A.E. tests (such as on the Vampire) are included. Simulation facilities (internal fans, hot jet apparatus, R.A.E. Jet Interference Tunnel) are described. Paper is most interesting presentation of problem and current methods of coping with it; authors point out many limitations which presently exist.

The influence of turbojet airflow on the aerodynamic design of airplanes, **Harold Luskin and Harold Klein:** Authors consider effects of turbojet airflow on aerodynamic longitudinal forces and movements of airplanes, along with other miscellaneous problems associated with turbojet airflow in both subsonic and supersonic flight. Computation of longitudinal force effects includes engine net thrust, skin friction, pressure drag and incremental scoop drag. Data are presented in the figures on inlet stagnation pressure losses (including shock losses), incremental scoop drag coefficients (Mach 2.0 case) as a function of mass-flow ratio. Miscellaneous problems considered include aspiration of particles into engine, buffeting, heating and noise caused by jets and inlet airflow nonuniformity.

Simulation of the effects of internal flow in wind tunnel model tests of turbojet powered aircraft, **Albert J. Evans:** Paper describes NACA practice of model-testing employing a large-scale model for detailed study of air inlet and inlet ducting, a smaller scale complete model to get over-all aerodynamic characteristics, and a third model to represent jet-nozzle and afterbody of airplane. Effects of inlet flow and jet exhaust on over-all aerodynamic characteristics are illustrated from model tests.

Boundary layers on swept wings, their effects and their measurement, **D. Küchemann:** Review of theoretical and experimental aspects of three-dimensional boundary layers, as arising on swept wings. Effect of boundary layer on lift slope, drag and the effects of boundary-layer separation are discussed and illustrated from various experimental works. Experimental instrumentation involved is described. Paper is a pertinent review of subject.

The use of pitot tubes in the measurement of laminar boundary layers in supersonic flow, **R. J. Monaghan:** Paper summarizes results of research on laminar boundary layers at R.A.E., describing and discussing effects of pitot size which, due to the distortion and displacement associated with the supersonic boundary layer, may lead to errors in measured values of displacement and momentum thickness. The simple correction factor obtained by Davies [unpublished Ministry of Supply paper] is shown to correlate with results obtained by Blue and Low [*NACA TN* 2891] and indicates that, if ratio of tube diameter to boundary-layer thickness is less than 0.2, the measured values of displacement and momentum thickness may be less than 4% above their true value. A method of manufacture of tapered quartz tips of circular cross section, which have a better response rate than flattened tubes of the same internal height, is described.

A method of calculating the three-dimensional boundary layer and application to an ellipsoid at an angle of attack, **E. A. Eichelbrenner and A. Oudart:** Paper presents a theoretical approach to the problem of three-dimensional boundary-layer calculations in incompressible flow, based on the use of equipotentials and streamlines in perfect inviscid flow and assuming that velocity normal to streamlines is small (restricting theory to small angle of attack case). Considerable results are presented and some comparison with experiment for the ellipsoid is shown.

A brief review of three-dimensional boundary layer flows, **W. R. Sears:** Author reviews subject, emphasizing independence between axial and crossflow layers in laminar and turbulent case. Concepts of boundary-layer separation as arising in the three-dimen-

sional case are discussed. Lack of correlation between implied independence of axial and crossflows for the turbulent layer is reviewed up to present state of knowledge.

The simulation and measurement of aerodynamic heating at supersonic and hypersonic Mach numbers, **Jackson R. Stalder and Alvin Seiff:** Authors review simulation parameters, assuming the Stanton number to be a function of Mach number, Reynolds number, Prandtl number, ratio of body surface temperature to boundary-layer edge temperature, transition Reynolds number, free-stream air temperature, body shape, surface temperature gradient and Knudsen number. Wind-tunnel and free-flight range simulation are discussed along with methods of measurement in these facilities.

The status of heat transfer and friction investigations at supersonic speeds, **H. H. Kurzweg:** Author makes a general review of subject for continuous, ideal, supersonic gas flow. The proportionality of temperature recovery factor for the laminar boundary layer to the square root of the Prandtl number (independent of Mach number) is reviewed in light of numerous experimental data and shown to be valid for flat plates and cones with attached shocks (where the temperature of the undisturbed flow is replaced by temperature at outer edge of boundary layer). Errors are introduced if this relation is applied where pressure gradients along the surface or temperature gradients within the surface are present, but even in the case of wind-tunnel measurements on a hemisphere with large gradients the deviation was shown to be small. For the turbulent boundary layer, the recovery factor on flat plates follows the cube root of Prandtl numbers and shows experimentally little change with Mach number. Author discusses further determination of heat-transfer coefficient and relation between friction and heat-transfer coefficients. Considerable number of experimental results are incorporated in this paper.

The N.R.C. icing wind tunnels and some of their problems, **C. K. Rush:** Author describes icing tunnel facilities of the National Research Council and discusses special problems associated with these facilities, such as formation of snow, freeze-out and humidity. Some of tests undertaken are described.

Wind tunnel simulation of atmospheric icing conditions, **C. K. Rush and R. L. Wardlaw:** Authors review techniques of simulating atmospheric icing conditions in wind tunnels, including production of water droplets, spray nozzle installation, cloud characteristics in variable ducts, temperature and state of the droplets, scale effects on ice growth, and measurement techniques (droplet size and spectrum).

The fluid flow associated with the impact of liquid drops with solid surfaces, **P. Savic and G. T. Boult:** Authors present theory for the fluid flow associated with impact of liquid drops on a surface and use spark camera to verify some aspects of theoretical predictions. General outline of pressure distribution is confirmed by impinging drops on a hot surface.

The icing problem—current status of N.A.C.A. techniques and research, **Uwe H. von Glahn:** Paper reviews and summarizes NACA work on aircraft icing problems. General scope of work and results are presented. Icing test facilities and techniques are described.

G. V. Bull, Canada

1758. Mark, H., The interaction of a reflected shock wave with the boundary layer in a shock tube, *J. aero. Sci.* **24,** 4, 304–306, Apr. 1957.

The purpose of the present note is to report some of the results of an analytical and experimental study, made at the Cornell University Graduate School of Aeronautical Engineering, of the interactions of the reflected shock with the boundary layer of the flow behind the initial shock and the effects of these interactions on the flow behind the reflected shock. From author's summary

1759. Parkin, B. R., and Kermeen, R. W., Water tunnel techniques for force measurements on cavitating hydrofoils, *J. Ship Res.* **1,** 1, 36–42, Apr. 1957.

Paper reviews briefly the experimental techniques and data-correction procedures developed in connection with studies in the High Speed Water Tunnel, California Institute of Technology, for hydrofoil force measurements. The matters discussed relate chiefly to problems of force measurement in cavitating flow and to procedures devised to solve them. Items considered in this connection are water-tunnel balances, the effects of tip-clearance flows, tare corrections, the importance of cavity-pressure measurements, cavitation scaling, tunnel-wall effects, and hydroelastic effects.

From authors' summary

1760. Smiley, R. F., and Horne, W. B., Vertical force-deflection characteristics of a pair of 56-inch-diameter aircraft tires from static and drop tests with and without prerotation, *NACA TN* 3909, 41 pp., Feb. 1957.

An investigation was made to obtain information on the vertical force-deflection characteristics of a pair of 56-in.-diam type I (smooth contour) aircraft tires under three conditions: static tests, drop tests without prerotation, and drop tests with prerotation up to 470 rpm. The experimental results together with a few simplified theoretical considerations indicated that a small but noticeable difference between the tire vertical force-deflection characteristics existed for these three conditions and that there might be similar differences between these characteristics and those for realistic landing conditions with finite horizontal velocity. Generally speaking, for increasing force, the tires are found to be least stiff for static tests, almost the same as for the static case for prerotation drop tests as long as the tires remain rotating, and appreciably stiffer for drop tests without prerotation.

The effects of the following factors on the tire force-deflection characteristics are also discussed: nature of the tire air-compression process, tire hysteresis, tire centrifugal forces, and drag loads. From authors' summary

Thermodynamics

(See also Revs. 1644, 1781, 1794, 1795, 1800, 1814)

Book—1761. Zeise, H., Thermodynamics based on quantum theory, quantum statistics and spectroscopy. Vol. 3, Part II: Graphical representations and the literature [Thermodynamik auf den Grundlagen der Quantentheorie, Quantenstatistik und Spektroskopie. Band 3, 2. Hälfte: Graphische Darstellungen und Literatur], Leipzig, S. Hirzel Verlag, 1957, 299 pp. (DM 22.20).

Book has two sections. One involves 142 figures which usually include experimental points and literature references. The second includes 706 references pertaining primarily to chemical thermodynamic properties of substances of engineering interest. A short discussion of each reference and subreferences are given. Heat capacities, equilibrium constants for chemical reactions, and compositions of a number of multicomponent systems at physicochemical equilibrium are presented. The book should be useful to persons interested in physicochemical equilibrium of fluids and solids. B. H. Sage, USA

1762. Potter, J. H., The third law of thermodynamics—a half-century appraisal of the Nernst heat theorem, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-185, 9 pp.

Author examines first, second, and, especially, third law in the language of classical thermodynamics. He dwells on certain properties like specific heat, which are related to but not essential to the third law and present no novelty of thought. Considering the paper as a general digest of the subject, there is an important omission by not mentioning the formulation such as that due to E. A. Guggenheim and to Fowler and Guggenheim, which reviewer considers most satisfactory.

Treatment is weak and lacks the preciseness and clarity which would be expected in papers of such nature.

L. S. Dzung, Switzerland

1763. Faggiani, D., Reversibility and irreversibility of thermodynamical processes (in Italian), *Ingegnere* **30,** 9, 825–833, Sept. 1956.

1764. Huetz-Aubert, Miss M., Contribution to the studies of specific heats of gases and vapors (in French), *Publ. sci. tech. Min. Air, France TN* 68, 182 pp., 1957.

Author presents voluminous discussion of specific heats of gases and vapors, and methods of measurement. Result of these considerations is to use an experimentally determined adiabatic compressibility with the isothermal compressibility determined from the equation of state. Apparatus is described for determining the adiabatic compressibility at low frequencies to assure the contributions of vibrational degrees of freedom. The method is applicable to a range of pressures and temperatures. Determinations of specific heat of CO_2 and of N_2O agree with spectroscopic values. Measurements of hydrocarbons are not subject to comparison with published data because of the wide variations in the latter.

M. A. Mayers, USA

1765. Jeener, J., Low temperature mixing calorimeter for liquids, *Rev. sci. Instrum.* **28,** 4, 263–265, Apr. 1957.

A technique is described for measuring the heat of mixing, excess volume, specific heat, and other thermodynamic properties of liquid systems at low temperature (e.g., CO, CH_4, A, Kr). Experiments are carried out at constant pressure, without any vapor phase in the calorimetric vessel.

From author's summary

Book—1766. Hutchinson, F. W., Thermodynamics of heat-power systems, Reading, Mass., Addison-Wesley Publ. Co., Inc., 1957, xix + 490 pp. $8.50.

This is another introductory thermodynamics textbook for mechanical engineering students. Brief sections on heat transfer, fluid flow, and nuclear reactors are included. There is very little engineering description of heat-power equipment. The treatment is held to a very elementary level throughout, frequent reference being made to more advanced texts, such as that of Keenan, for more detail. The reviewer was bothered by numerous examples of relationships presented without explanation which in reality follow from rigorous thermodynamic arguments, the reader being left free to assume that they are empirical.

R. Friedman, USA

1767. Bosley, D. B., Leddick, R. S., and Drucker, E. E., A fundamental approach to the analysis of steam surge tank transients, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-269, 8 pp.

Paper discusses problem of pressure changes in a water loop including steam-cushioned surge-tanks with particular reference to conditions during power variation in a pressurized-water nuclear reactor. Authors cite experimental evidence showing that heat transfer from the steam cushion significantly lessens the pressure surge during a power increase.

A simplified thermodynamic model of the process in the surge-tank is considered and the resulting equations are solved on an analog computer. A compressibility factor representation of steam properties near saturation is used to facilitate computation. Effects of heat transfer are introduced by empirically adjusting results from equations until agreement with pressure-surge data is obtained. Authors find that, for particular situation investigated, amount of steam condensed is small and heat transfer from steam is mostly due to natural convection. For very rapid pressure surges, isentropic compression is approached, while for slow surges, compression along the saturation line is nearly obtained.

As thermodynamic analysis of steam in tank assumes reversibility, equilibrium conditions, and constant mass, reviewer believes that results are valid only for very restricted situations.

R. L. Young, USA

1768. Keller, G., Operating experience and design features of closed-cycle gas-turbine power plants, *Trans. ASME* **79,** 3, 627–643, Apr. 1957.

1769. Gaehler, W., The first industrial closed-cycle air turbine plant employing pulverized coal, *Escher Wyss News* **29,** 2, 49–54, May–Aug. 1956.

1770. Spiess, H., The vapour compressor in the energy economy, *Escher Wyss News* **29,** 2, 61–64, May-Aug. 1956.

1771. Cohen, C. B., Woollett, R. R., and Weston, K. C., Thermodynamic study of a Roots compressor as a source of high-temperature air, *NACA TN* 4025, 34 pp., June 1957.

A Roots compressor is analyzed to determine the feasibility of using the device as a source of high-temperature air for high-speed research equipment. The cycle is idealized by the transport of an amount of air from the inlet to high-pressure side of the compressor where it undergoes a polytropic compression. Some outlet air is returned to the inlet as leakage bypass where it mixes with supply air to form the inlet air. Equations for the polytropic exponent, heat loss, leakage, speed, power and size are derived as functions of the Stanton number, inlet temperature and pressure, outlet temperature and pressure, and the compressor wall temperature. Curves showing the effects of the various parameters on the power, speed and size are given for outlet temperatures of 7000 R. Since the assumptions critically affect the design, the assumptions were selected to give conservative results.

A discussion of the effect of the Stanton number of the design is presented, and estimates of limiting values are given. More data are needed regarding the expected values of this important parameter. For an outlet temperature of 7000 R, a Stanton number of 0.0014, wall temperature of 2000 R, supply temperature of 4000 R and an inlet pressure of 3 atmospheres, the rotors would have a 4-ft diameter, clearness of 0.1 inch, speed of 750 rpm, and a required horsepower of 9000.

R. G. Nevins, USA

1772. Haywood, R. W., Thermodynamic study of the number and positioning of the feed pumps in the feed train of a regenerative steam cycle, Instn. mech. Engrs., Prepr., 9 pp., 1957.

In this paper an approximate method of analysis is developed to compare the performance of single-pump and split-pump schemes in the non-reheat regenerative steam cycle. The analytical result is shown to agree closely with figures obtained by detailed calculations based on the same standards of comparison of the two schemes as those used in the approximate analysis, although on an alternative basis of comparison the calculated difference between the performances of the two schemes is smaller. The study reveals, however, that on either basis of comparison the efficiency of the cycle is slightly greater for the split-pump arrangement. Detailed calculations for a typical reheat cycle show the same tendency. It is concluded that, on the score of both thermal efficiency and capital cost, the split-pump arrangement is to be preferred.

From author's summary

1773. Ainley, D. C., Estimation of the change in performance characteristics of a turbine resulting from changes in the gas thermodynamic properties, *Aero. Res. Counc. Lond. Rep. Mem.* 2973, 13 pp., 1956.

Frequently turbines are tested in a laboratory with cool air which has thermodynamic properties different from those of the

hot gas for which the turbine is designed. This note presents methods for correcting such tests to allow for a difference in gas thermodynamic properties. From author's summary

1774. Semiconductor thermoelectric generators and refrigerators and their applications, Infosearch, Russian Literature Survey SEM-1-56, 8 paps., Aug. 1956.

1775. Wills, J. L., and Tech. Subcommittee No. 2 of the Cooling Tower Institute, Instrumenting a field study of industrial water-cooling tower performance, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-22, 5 pp.

1776. Codegone, C., Isothermal elasticity modulus of water (in Italian), *Monogr. Lab. Aero. Politecn. Torino* **89,** 357, 4 pp., Nov. 1954.

Heat and Mass Transfer

(See also Revs. 1625, 1651, 1772, 1775, 1804, 1830)

1777. Longmire, C. L., Method for determining thermal conductivity at high temperatures, *Rev. sci. Instrum.* **28,** 11, 904-906, Nov. 1957.

An analytical paper which discusses a method for determining thermal conductivity of solids. The solid material is formed into a rod of rectangular cross section and is heated by passing an electric current through it. Since the cross section is rectangular, the surface temperatures at the centers of the long and short faces will differ from each other, and this difference is shown to be dependent on the thermal conductivity of the material. An approximate equation is derived which yields the thermal conductivity in terms of the dimensions of the rectangular cross section, the surface temperatures at the centers of the faces, and the surface emissivity. It is mentioned that this method has been applied successfully to measure the thermal conductivity of graphite at temperatures near 2500 K. R. Siegel, USA

1778. Vestal, D. M., Jr., and Fluker, B. J., The design of a heat pump buried coil, *Texas Engng. Exp. Sta. Bull.* 139, 33 pp., Aug. 1957.

1779. de Vries, D. A., On the integration of the heat-conduction equation with periodic variation of temperature, *J. Meteor.* **14,** 71-76, Feb. 1957.

A simple integration of the Fourier equation of heat conduction in a semi-infinite medium is presented for the case where the thermal diffusivity varies with depth, assuming a harmonic variation of temperature with time. H. Arakawa, Japan

1780. Naruoka, M., and Hirai, I., On the temperature analysis of the bridge slab, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 377-380.

Paper deals with the analysis of transient temperature distribution in single and composite slabs by the use of electrical analog circuits. While it is well known that a filter-type resistance-capacitance circuit serves as an exact analogy for heat flow in slabs, the transient temperatures are not determined from measured electrical data as is commonly done but from solutions deduced from the equivalent electrical circuit. Analogous expressions were given for the following two cases:

(1) One surface of the slab is subjected to sinusoidal temperature change while the other surface is perfectly insulated.

(2) One surface of the slab is subjected to sinusoidal temperature change while the other is kept at zero.

When the amplitude and phase angle of the temperature at an arbitrary location in a composite slab were known for frequencies ranging from $\omega = 0$ to $\omega = \infty$, the response or memory function of that point, $f(t)$, due to an impulse input temperature could be determined by means of Fourier transformation. The transient temperatures at that location due to any surface temperature changes were then obtained by Duhamel's theorem.

Temperatures measured by thermocouples embedded in a concrete slab covered with asphalt compared favorably with theoretically calculated values. B. T. Chao, USA

1781. Gafner, G., The application of a transient method to the measurement of the thermal conductivity of rocks and building materials, *Brit. J. appl. Phys.* **8,** 10, 393-397, Oct. 1957.

Apparatus will quickly measure conductivity of materials ranging from 0.45 to 4.00 Btu/(hr) (sq ft) (°F/ft) with 7% accuracy. Heat from a controlled source passes through a 2.75-in. diameter to a guarded and known heat capacity sink. A fixed temperature difference is maintained between source and sink during transient test and conductivity determined from rate of rise of the sink. Contact resistance is determined from measurements on a series of thicknesses. A. C. Mueller, USA

1782. Schmidt, F. H., On the diffusion of heated jets, *Tellus* **9,** 3, 378-383, Aug. 1957.

Paper describes a simple theoretical analysis of two-dimensional and axially symmetric heated turbulent jets. The analysis assumes similarity of the velocity and temperature profiles as well as the intensities of the turbulent fluctuations of velocity and temperature. Moreover, a particular solution is assumed in such a way that the jet boundary is constrained to expand in proportion with the distance from the origin. The resulting equation for conditions along the midplane or axis reduces to the limiting solutions of Tollmien for isothermal jets and W. Schmidt for heated jets with negligible inlet momentum (i.e., free convection from a source). It amounts to an averaging of the cube of the velocities calculated for each of the two limiting cases. The analysis does not yield any direct information concerning the radial temperature or velocity profiles. However, author argues qualitatively for a finite profile equation, rather than the often-used error function. His proposed equation is compared with extremely scattered data.

Reviewer thinks equations for midplane and axial conditions may prove useful in analyzing real heated jets, in spite of their rather heuristic derivation. Argument concerning transverse profiles is not impressive, and "support" claimed from plotted data is not borne out by the figures. R. R. Hughes, USA

1783. Johannes, C., and Kraybill, R. R., Heat transfer and pressure drop in odd-shaped annulli, ASME-AIChE Heat Trans. Conf., University Park, Pa., Aug. 1957. Pap. 57-HT-26, 10 pp.

1784. Powell, W. B., Heat transfer to fluids in the region of the critical temperature, *Jet Propulsion* **27,** 7, 776-783, July 1957.

Data for forced convection heat transfer have been experimentally obtained with oxygen at supercritical and subcritical pressures. The correlation of the data shows that a minimum in the heat-transfer coefficient exists at the critical temperature which is appreciably lower than at either lower or higher temperatures.

Data were correlated by use of an expression obtained from $Nu = 0.023\ Re^{0.8}\ Pr^{0.4}$ by equating terms depending on the experimental program to terms representing the physical properties of the fluid. The expression containing just the experimental quantities was plotted against the bulk fluid temperatures at various tube wall temperatures. C. C. Eckles, USA

1785. Mueller, W. K., Heat-transfer characteristics of periodically pulsating turbulent pipe flow, Proc. Fifth Midwestern Conf. fluid Mech., Univ. of Mich., Apr. 1957, 146-159.

Author summarizes as follows:

"For those turbulent pulsating flows which may be considered as quasi-steady, the average Nusselt number is shown to be always less than the corresponding steady-flow Nusselt number. A criterion is presented for judging whether a particular pulsating flow may be considered as quasi-steady. Experimental results of pulsating turbulent pipe-flow heat-transfer tests are presented."

Reviewer feels that the physical model used to simplify mathematical treatment is crude, and the assumptions are nonconvincing. Results of measurements are inconclusive.

L. S. Dzung, Switzerland

1786. Ainley, D. G., Internal air-cooling for turbine blades—a general design survey, *Aero. Res. Counc. Lond. Rep. Mem.* 3013, 40 pp., 1957.

A well-derived method is presented for prediction of air-cooling capacity in various configurations of smooth passages through turbine blades (radially oriented). Laminar, as well as turbulent, cooling air flow is treated and correlated for wide range of Reynolds number, and for basic turbine design data. Definition of essential requirements for high cooling efficiencies provides a selective system which permits the formulation of blade design considerations. Cooling flow ratios (cooling air mass flow-blade/gas mass flow-blade) between 0.005 and 0.020 are used in the treatment which is compared with experimental work, showing that the analytical method tends to overestimate the heat transfer. The cooling characteristics show, nevertheless, very attractive results.

Although similar work has been conducted in Germany (Junkers, B.M.W. and others) and later in U.S.A. by N.A.C.A., reviewer believes that this presentation offers a directly applicable design tool for air-cooled turbine blade design. C. R. Bell, USA

1787. Struser, L. R., Accidental errors in evaporation values calculated by the method of turbulent diffusion (in Russian), *Trudi Gos. Gicbolog. in-ta* no. 48, 66–86, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7588.

To determine the intensity of evaporation E by the method of turbulent diffusion, the following formulas are used

$$E = 2.1\ K\Delta e\ (mm/hr);$$

$$K = 0.104\ \Delta u\ [1 + 1.38\ (\Delta t/(\Delta u)^2)]\ (m^2/\text{sec});$$

where Δe, Δu, Δt are the differences of the absolute humidity, wind velocity, and temperature, at the altitudes of 1.5 and 0.5 m, counting from the boundary of the displacement layer, K has the significance of the coefficient of (turbulent) exchange at the altitude of 1 m. The total diurnal evaporation is calculated with the help of the interpolation formula

$$U = \sum_{\nu=1}^{m} a_\nu \tau_\nu \widetilde{E}_\nu$$

in which E_ν = mean intensity of evaporation in the time interval τ_ν; a_ν = numerical coefficients.

Author analyzes errors arising in the determination of E and U, and caused by accidental errors in the measurement of the gradients. These can be very considerable. Thus, an example is given of the measurement of Δe by eight different instruments arranged in a single row, during nine successive time intervals of 7 minutes each; the value of Δe for each seven-minute period was taken as the mean of three readings made during these seven minutes. The 72 values of Δe thus obtained have a (statical) distribution approaching the normal, with a mean value of 0.435 millibar and a standard deviation of 0.396 millibar.

From 11 series of gradient measurements, made at three different geographical points, the mean values of the standard deviation and the coefficients of variation Δu, Δt, Δe and E are determined; thus, for instance, the (percentage) values of the coefficients of variation have been found equal to 0.35, 0.98, 1.09, and 1.45, respectively. From these data, the relative error has been determined in the calculation of E, V and the quinqueduirnal total evaporation, depending on the value of the reliability coefficidnt α. According to the results obtained, in order to insure a relative error not exceeding 30% in 95% of all cases, the following numbers of measurement series are required: for determining U—65; for the hourly mean of E—90; for the quinquediurnal total evaporation—15–20 series per diem.

It is concluded that the data obtained from a network of observation points (stations) are unsuitable for determining the diurnal evaporation totals, and still more so, for the diurnal rate of the intensity of evaporation.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1788. Merkulov, A. P., Investigation of a turbulent-flow cooler (in Russian), Thesis, Moscow Aviation Inst., Moscow, 1956; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7580.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1789. Gerasimov, Ya. A., and Kozlov, B., The temperature of an open space of water (in Russian), *Nauch.-issled. prom-sti* no. 1, 115–118, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5986.

A study is made of the temperature developments of the surface of water in open containers, the water surface being in contact with the atmosphere. From the elementary equation of heat equilibrium is deduced the temperature of the surface of the water. The significance of the parameters is shown in the dependence of the development on the movement of the liquid— laminar, (ripple) forming and turbulent. Examples are cited of calculations for the temperature of the water surface and the rate of evaporation.

E. M. Dobryshman
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1790. Gupta, R. K., and Katz, D. L., Flow patterns for predicting shell-side heat transfer coefficients for baffled shell-and-tube exchangers, *Indust. Engng. Chem.* **49,** 6, 998–999, June 1957.

Based on visual observation of the flow in a glass shell-and-tube heat exchanger with one baffled shell pass, authors divide the shell-side flow pattern into three distinct zones: (a) longitudinal flow through the baffle cuts, (b) crossflow across the tube bundle along the baffles opposite the baffle cuts through which the flow enters each baffle compartment, (c) eddy zones adjacent to the baffles on the side where the flow enters each baffle compartment. The relative magnitudes of these regions appear to depend mostly on baffle spacing and baffle cut, but hardly at all on flow rate.

Operating this exchanger with 60–80% propylene glycol in water on the shell side, authors have determined shell-side heat-transfer coefficients for a number of flow rates, baffle spacings, and baffle cuts. The experimental shell-side coefficients are then equated to a weighted average of individual shell-side coefficients for the longitudinal flow, crossflow, and eddy zones. The weighting factors are the visually estimated fractions of the total heat-exchange area in each flow region. Longitudinal flow and cross-flow coefficients are computed from known Nusselt-Reynolds-Prandtl number correlations, and eddy-zone coefficients are estimated by difference. A plot of $Nu/Pr^{0.33}$ versus Reynolds number for the eddy zone is shown which scatters rather badly at low Reynolds numbers, probably because eddy-zone coefficients were determined by difference and because of the difficulty in defining a meaningful Reynolds number for the eddy zone. A plot of shell-side pressure drop is shown which exhibits the 1.8th power dependence on mass velocity characteristic of turbulent pipe flow.

Since the eddy-zone coefficients were calculated from effective shell-side coefficients originally, no gain in accuracy is achieved in estimating effective shell-side performance by using the eddy-zone correlation in this paper. The one-third power effect of Prandtl number seems to have been copied from other correlations without direct experimental evidence to show that it applies to the eddy zone. On the other hand, a correlation of effective shell-side coefficients for various baffle arrangements, which is also presented, has considerable practical value

A. W. Gessner, USA

1791. Wolf, H., and Lehman, J. H., The determination of thermal entrance lengths for gases in turbulent flow in smooth round ducts, *Jet Propulsion* **27,** 8 (Part 1), 897–899, Aug. 1957.

1792. Tea, P. L., Jr., and Baker, H. D., A model method for determining geometric factors in solid-to-solid radiation heat transfer, *Trans. ASME* **80,** 2, 367–372, Feb. 1958.

Many times in years past, when spending hundreds of hours on the interreflection of light and radiant heat, devising incremental methods of solution, and applying the methods to cases, I often dreamed of devising instrumental means for handling these difficult situations. I never got anywhere. But the authors have made their dreams come true. They have done the complete job, by presenting us with an adjustable model which has plane diffusing sources, surfaces for reception and diffuse reflection, and a completely adequate detector. Here is a welcome tool, proved in, and ready for use.

To give an idea: I once worked out a case of simple geometry in which each of the first several interreflections required forty hours of work. Actual experience of this kind tells, as nothing else can, the need for instrumental methods.

A couple of mechanical engineers have now done what we in electrical engineering should have done long since. Congratulations to them!

A. D. Moore, USA

1793. Griffith, P., Bubble growth rates in boiling, ASME-AIChE Heat Transfer Conference, University Park, Pa., Aug. 1957. Pap. 57-HT-2, 6 pp.

1794. Reynolds, W. C., and Kays, W. M., Blowdown and charging processes in a single gas receiver with heat transfer, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-137, 9 pp.

Authors derive thermodynamic equations for blowdown and charging processes. Simplified solutions are presented for isothermal, adiabatic, constant-mass flow with heat transfer, variable-mass flow through a critical-flow nozzle with heat transfer, and constant-mass flow with negligible resistance to heat-transfer situations. Criteria for the applicability of each of these simplified solutions are presented.

Experimentation is reported which confirms theoretical results for the case of blowdown through a critical-flow nozzle with heat transfer. Means of evaluating the heat-transfer coefficient are also presented.

Primary assumptions include perfect gas behavior of fluid, constant heat-transfer coefficients, and perfect mixing of fluid. Authors claim that, for adiabatic charging processes where perfect mixing is not attained, use of mean values for temperature and pressure yield reliable results. Analysis apparently neglects kinetic energy of flow stream which, reviewer believes, might be a significant energy term in certain situations.

Reviewer recommends this paper as a fine discussion of an important topic which has received very little attention.

R. L. Young, USA

1795. Hyman, S. C., and Joseph, L., Control of flow distribution by mixing headers, ASME-AIChE Heat Trans. Conf., University Park, Pa., Aug. 1957. Pap. 57-HT-30, 15 pp.

Paper describes the effect of interrupting a system of parallel fluid flow paths through a power source such as a nuclear reactor by a mixing header which can be thought of as a "shorting" device. This "short circuit," located perhaps midway along the flow path, can act to different extents as a temperature equalizer for the fluid entering the last half of the parallel flow paths. In addition, the header acts as a pressure equalizer. The authors' point is that sensitivities of maximum surface temperatures, outlet temperatures, and flow rates to variations in heat-transfer rates along the different parallel flow paths can be reduced if an intermediate mixing header is used along the flow path through the device. These local variations in heat-transfer rate might be due to manufacturing tolerances adding up at a particular location, or due to maldistributions of fissionable fuel material. A method of calculating the sensitivities of the various parameters to non-uniformities in heat flux is discussed and an illustrative example for a supercritical water boiler is presented. As might be expected, results of the calculations show that the sensitivities of the various parameters are extremely dependent on the degree of mixing "assumed" to take place in the header.

One gets the impression that the authors have developed another method of presenting engineering data rather than having developed any new design concepts not already, at least implicitly, employed in the existing pressurized water reactor designs.

R. S. Wick, USA

1796. Tschinkel, J. G., and Graves, A. E., Peroxide warm-up equipment, *Jet Propulsion* **27,** 7, 796–798, July 1957.

1797. Bosnjakovic, F., Heat and mass transfer with humid gases (in German), *Kaltetechnik* **9,** 10, 309–313, Oct. 1957.

Combustion

(See also Rev. 1688)

1798. Heimel, S., Effect of initial mixture-temperature on burning velocity of hydrogen-air mixtures with preheating and simulated preburning, *NACA TN* 4156, 23 pp., Oct. 1957.

Paper is specific contribution to broaden the understanding of combustion phenomena, using hydrogen-air mixtures (also propane-air for comparison) for experimental correlation with previous work in this field. Initial mixture temperatures from 287 K to 700 K were used for 25% to 45% mixtures. Effects of preheating were treated in terms of flame temperatures, burning velocity and mass burning rate. It has been established that the mole-for-mole substitution of water vapor by nitrogen did not cause considerable change in burning velocities. Well-organized graphs and references are included.

C. R. Bell, USA

1799. Shen, S. F., Effect of chemical reaction on the inviscid criterion for laminar stability of parallel flows, Proc. Fifth Midwestern Conf. Fluid Mech., Apr. 1957, 11–21.

Author gives a mathematical treatment of periodic fluctuations of flow properties of inviscid stream in which chemical reaction is represented by source of energy and sink of material of strength depending on concentration and temperature. Method of linearizing omits all molecular transport terms.

Complicated equations resulting are discussed, but fact that coefficients are complex makes it unlikely that real "inviscid criterion" exists. Methods of further examination of equations and their bases are suggested.

M. A. Mayers, USA

Book—1800. Bosnjakovic, F., Enthalpy diagram for gasification, combustion, and soot formation [Wärmediagramme fur Vergasung, Verbrennung und Russbildung], Berlin, Springer-Verlag, 1956, x + 150 pp. + 69 tables. DM 43.50.

Book is useful for both scientists and engineers working on gasification and combustion processes.

The first part describes and discusses the processes and their equilibria; the second part contains 70 enthalpy diagrams for 1, 10, and 25 atm, for gasification with air and with oxygen for coke and other fuels, etc.

The enthalpy-carbon content diagram of Bosnjakovic is of great help to see into the complex processes of heat transfer and chemical reactions which are involved in gasification.

A. Erdelyi, Switzerland

1801. Pfenninger, H., Mode of operation and design of Brown Boveri gas turbines, *Brown Boveri Rev.* **44,** 4/5, 190–199, Apr./May 1957.

1802. Kind, C., Equipment and tests in Brown Boveri's Combustion Laboratory, *Brown Boveri Rev.* **44,** 4/5, 218–224, Apr./May 1957.

1803. Schelkin, K. I., Phenomena in the vicinity of the origin of a gas detonation (in Russian), *Zh. eksp. teor. Fiz.* **29,** 2, 221–226, 1955; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 7251.

A theory already suggested by the author [*Doklady Akad. Nauk SSSR* **23,** p. 636, 1939; *Zh. eksp. teor. Fiz.* **24,** p. 589, 1953] for the transition from gradual combustion to detonation in a gas is further developed. According to this theory, the acceleration of the flame front causes the formation of a powerful shock wave which produces detonation at some distance in advance of the flame front.

It is now assumed that cases may occur in which the temperature rise in this shock wave is insufficient to produce detonation. In this case, according to the author, at the instant when the flame reaches the high temperature region beyond the shock wave, the velocity of the flame front greatly increases. This causes the formation of a second shock wave which may lead to detonation directly in advance of the flame front.

G. M. Bam-Zelikovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1804. Privalova, K. A., An experiment with the use of multiple-jet gas burners in steam boilers (in Russian), *Trudi in-ta isol' zovaniya gaza Akad. Nauk USSR* 3, 102–104, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7271.

Existing jet burners with a capacity exceeding 30–40 m^3/hr of gas are exceedingly bulky. The installation of a number of gas jets instead of a single burner enables the axial dimensions of the burner to be considerably reduced.

Results are given of tests with a Dürr-type boiler equipped with a four-jet burner of a capacity of 100 m^3/hr and a length of 1300 mm.

Losses due to chemically incomplete combustion were found to be nil. Although neither an economizer nor an air preheater were fitted to the boiler, the temperature of the flue gases never rose above 140–170°. The efficiency of the boiler equipped with the multiple-jet burner was found to be 20–25% higher than that of a boiler with a burner of any other type.

M. V. Polikovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1805. Miesse, C. C., On the combustion of a liquid fuel spray, Sixth (International) Symposium on Combustion, New York, Reinhold Publ. Corp., 1957, 732–738.

Survey of recent literature on atomization, evaporation, and combustion lists, in particular, articles on the combustion of single drops and of fuel sprays. Author discusses theoretical concepts for explaining some of the observed phenomena: (1) variation of performance characteristics with the method of injection, i.e., finer and coarser atomization; (2) variation of available propellant vapors with distance; (3) spatial variation of average drop size. Difference in burning rates of large (1000 micron) and of smaller (50 micron) single droplets. Author assumes an idealized combustion chamber for a liquid propellant and sets up the differential equation for the reacted and unreacted quantities in a cross-sectional slice which travels downstream from the injector. Under simplifying assumptions the vaporized propellant reaction, and the atomized propellant reaction, and analyzed. The variation of the ratio of flame to droplet radius is plotted for benzene and ethanol drops. The diffusion hypothesis of Goldsmith and Penner is used to determine the flame-front radius.

Some conclusions are: (1) The performance of a liquid-propellant combustion is dependent upon two dimensionless groups which are equal to the product of the reaction frequency and the gas residence time, or droplet lifetime. (2) An increase in the value of either of the above dimensionless parameters leads to higher performance. (3) The ratio of flame to drop radius decreases with drop diameter, with a corresponding increase in burning rate. (4) The stability of the flame front surrounding a single fuel drop is increased by an increase in the burning rate, or by a decrease in the size of the drop.

K. J. De Juhasz, Germany

Acoustics

(See also Revs. 1593, 1643, 1652, 1678, 1799)

Book—1806. Hunter, J. L., Acoustics, New York, N. Y., Prentice-Hall, Inc., 1957, xv + 407 pp. $8.50.

For the most part, this is a standard undergraduate textbook on the physics of acoustics, much like numerous books that have preceded it. Other than minor rearrangements in the order of presentation, the book covers the usual elementary vibrating mechanical system, its electrical and acoustical analogs, the vibrating string, plane waves, acoustic filters, spherical waves, sound radiation from circular piston, performance of typical dynamic and horn-type loudspeakers, standard types of microphones, psychophysiological acoustics, architectural acoustics, ultrasonics, and underwater sound. An interesting chapter is devoted to sound-recording methods, including optical, magnetic tape and disks, and another one to sound-measuring apparatus, including reciprocity calibration, acoustic interferometry, the sound spectrograph and other instrumentation. As usual in such texts, the scope of ground covered restricts the discuss . of special topics to rather elementary levels.

Author appears to have taken extra care to explain fundamental concepts and assumptions often left vague in previous works. This has made the text easy to understand and rather pleasant to read.

W. W. Soroka, USA

1807. Lamb, G. L., Jr., On the transmission of a spherical sound wave through a stretched membrane, *J. acoust. Soc. Amer.* **29,** 10, 1091–1095, Oct. 1957.

The transmission of a spherical sound wave through a homogeneous stretched membrane of infinite extent is investigated theoretically. An integral representation of the transmitted sound field is initially derived. The path of integration is then transformed into the complex plane and the integration carried out in an approximate manner by the method of stationary phase.

The transmitted sound field is found to be composed of two parts, an outgoing spherical wave modified by an amplitude factor containing angular dependence, and a surface wave. The surface wave, which results from the free flexural vibration of the membrane itself, exhibits an interesting "zone of silence" in the transmitted sound field.

From author's summary by M. J. P. Musgrave, England

1808. Paul, D. I., Acoustical radiation from a point source in the presence of two media, *J. acoust. Soc. Amer.* **29**, 10, 1102-1109, Oct. 1957.

Two semi-infinite isotropic media (porous or nonporous) are separated by a plane interface. A simple point source of sound is imbedded in either of the media. Expressions for the resultant wave function are obtained by the method of steepest descents as modified by Banos and Wesley. In particular, two different asymptotic solutions are presented. The first solution is valid in the vicinity of the interface. The expansions, calculated out to three terms, yield the wave solution as a continuous function of the parameters of the two media and the space coordinates for horizontal ranges beginning at small distances from the source and extending to infinity. It is shown that a surface wave exists and that this wave gradually disappears when the horizontal range becomes sufficiently large. The second solution consists of a simple three-term asymptotic expansion valid in the vicinity of the vertical axis. The mathematical treatment uses a new path of integration not found in the literature on this problem.

From author's summary by M. J. P. Musgrave, England

1809. Silberman, E., Sound velocity and attenuation in bubbly mixtures measured in standing wave tubes, *J. acoust. Soc. Amer.* **29**, 8, 925-933, Aug. 1957.

Experimental measurements on air bubbles in water at frequencies from 60 to 20,000 cps, concentrations of 0.03 to 1%, and uniform sizes of 0.08 to 0.26-in. diameter (except for one series of experiments with two discrete sizes) show the expected agreement with available theoretical considerations. Near bubble resonance, high attenuation permits only measurements of the velocity.

F. E. Borgnis, USA

1810. Hueter, T. F., Boundary losses associated with acoustical streaming, *J. acoust. Soc. Amer.* **29**, 6, 735-736, June 1957.

The response of an acoustic thermocouple probe to ultrasonic pulses of 0.005 to 1 sec duration exhibits a sharp transition from low to high boundary dissipation at a critical sound level which depends on frequency. This transition is related to acoustical streaming phenomena in the boundary layer of the thermocouple wire. A connection seems to exist between the onset of turbulence and the formation of cavitation nuclei, although gross cavitation has not been observed.

From author's summary

1811. Lenskii, V. S., Acoustic variant of the theory of spalling (in Russian), *Prikl. Mat. Mekh.* **20**, 4, 552-554, July-Aug. 1956.

Theoretical investigation of spall effects produced by sound waves on a plane body of certain thickness is presented on the basis of principles relating to vibrations caused by impact of mechanical forces. Two facts are emphasized: (1) Full or nearly full absence of plastic deformation in the neighborhood of cracks and spalls, as shown by microstructural analysis; (2) resistance against spalling or cracking of steel plates caused by acoustic vibration depends only slightly on properties of standardized material. Reference is made to publications by D. Raynhart, G. Kolskiy, K. B. Broberg, W. A. Allen, J. Pearson and J. Rinehart, and O. E. Vlasof.

J. J. Polivka, USA

1812. Lindsay, R. B., and Eden, D. D., The acoustical properties of steam, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-190, 10 pp.

Authors describe apparatus for measurements of velocity of sound in steam at high frequencies and its attenuation. Basic theory is given for connecting the results of such measurements with estimates of the second virial coefficient in the equation of state. Attention is also called to the possibility of determining time of thermal relaxation.

Apparatus is described in great detail and some calibrations are given. No acoustical data in steam are reported.

M. A. Mayers, USA

1813. Sanders, N. D., and Laurence, F. C., Fundamental investigation of noise generation by turbulent jets, *SAE Trans.* **65**, 244-249, 1957.

Lighthill's classical analysis of jet noise is based on replacing turbulent flow by distributed stationary quadripoles of proper strength. Difficulty has been to relate theory to measurable parameters. Authors report theory (not detailed here) which relates quadripole strength to components of turbulent velocity. Theory shows general agreement with measurements on 3½-in. diameter cold-air jet. Shape of a turbulent eddy approximates ellipsoid of revolution with long axis parallel to jet axis. Noise generation for downstream is maximum close to center line; upstream, maximum becomes larger and approaches jet "surface." Total power per unit length is small beyond 10 diameters downstream in cold jet. Frequency of peak in noise spectrum decreases as measurement position moves downstream; slope agrees roughly with theory. Total sound power shows predicted linear relation to Lighthill parameter $\rho_0 S V^8 / C_0^5$ (density, jet area, jet velocity, sound velocity in surrounding medium) for model and full-scale jets. Some afterburner points are off curve.

V. Salmon, USA

1814. Henderson, M. C., and Peselnick, L., Ultrasonic velocity and thermal relaxation in dry CO_2 at moderate pressures, *J. acoust. Soc. Amer.* **29**, 10, 1074-1080, Oct. 1957.

Velocity and attenuation measurements are made for carbon dioxide (CO_2) for frequency ranges from 300 kilocycles to 7 megacycles and for pressure from 0.3 to 250 atmospheres. The measurements were made with a Hubbard-type interferometer. When the results were plotted in terms of a frequency-density ratio rather than the usual frequency-pressure ratio, it was found that the relaxation time was a linear function of this ratio. It was concluded that thermal relaxation effects, i.e. the transfer of rectilinear to vibrational modes of energy, accounted for the extra absorption of sound and the velocity dispersion in CO_2. It requires about 48,300 collisions to excite the internal modes, irrespective of the density. An increase in velocity occurs due to the nonideality of the gas.

W. P. Mason, USA

1815. Schuele, D. E., Gutowski, F. A., and Carome, E. F., Interferometric determination of ultrasonic absorption in castor oil, *J. acoust. Soc. Amer.* **29**, 10, 1081-1085, Oct. 1957.

Measurements have been made of the attenuation of sound waves in castor oil at a frequency of 3 megacycles for a temperature range from 10 C to 45 C. At the low temperature the attenuation is about 0.6 that of the classical value calculated from the measured viscosity of the liquid, while at high temperatures the measured attenuation is 1.5 times the classical value. No conclusions are given of the mechanisms operating.

W. P. Mason, USA

1816. Hubbard, H. H., Some experiments related to the noise from boundary layers, *J. acoust. Soc. Amer.* **29**, 3, 331-334, Mar. 1957.

Paper presents the main results of several recent experiments relating to the generation of noise in boundary layers. An attempt is made to correlate data obtained from a wind tunnel, a rotating disk, a helicopter rotor, and an aircraft in flight. These data provide evidence as to the mechanism of noise generation in the boundary layer and show how the noise varies as a function of velocity, density, and surface roughness. Some discussion is also given with regard to the relative importance of the boundary-layer noise and the noise from the power plant in high-speed jet aircraft.

From author's summary

Ballistics, Detonics (Explosions)

(See also Revs. 1688, 1702, 1803)

1817. Krebs, R. P., Effect of fluid-system parameters on starting flow in a liquid rocket, *NACA TN* 4034, 20 pp. + 1 table + 19 figs., Sept. 1957.

Rapid build-up of thrust immediately following the firing of a rocket is desirable from several points of view, such as guidance effectiveness and fuel economy. However, too rapid generation of thrust will cause excessive values of the so-called suppression head (pressure drop between propellant tank and pump inlet), leading to cavitation of the pump impeller.

The present paper makes an analytical study of the influence of configuration parameter and valve opening rate on the flow response and suppression head of a simplified rocket system, consisting of tank, pump, combustion chamber, valves and lines, including bypass.

The results indicate that the change of main valve area with time is the major factor influencing the suppression head and speed of response. The maximum suppression head varies directly with the length of the suction line between propellant tank and pump inlet; and varies inversely both with the internal cross section of this flow line and with the valve opening time. Other factors have little effect. F. L. Wattendorf, USA

1818. Benecke, T., and Quick, A. W., edited by, History of German guided missiles development, (AGARDograph 20), Brunswick, Germany, Verlag E. Appelhans & Co., 1957, viii + 420 pp.

Soil Mechanics, Seepage

(See also Revs. 1586, 1592, 1647, 1651)

Book—1819. Henry, F. D. C., The design and construction of engineering foundations, New York, McGraw-Hill Book Co., Inc., 1956, xviii + 547 pp. $9.50.

In the eleven chapters of the book everything is introduced that belongs to the description of foundation soils, to their properties and site investigation, as well as to the design and construction of foundations, with the exception of some details, e.g., injection of soils. But the book contains much more; reviewer thinks that there scarcely can be found a book on foundation engineering with such a breadth of aspects: geological aspects are introduced as systematically as the principles of soil mechanics and as the questions concerning the behavior of superstructure and its design. A systematic analysis of all problems from a modern point of view is given, in accordance with the real properties of materials and the behavior of structures. Each problem is accompanied by one or more examples from practice, naturally mostly from Great Britain, the collection of references being also rich.

In seven appendices, detailed computations, examples and deductions of formulas are given, as the author purposely avoids graphs and tabulated solutions in order to train young designers in finding statical influences and evaluating the importance of different factors. But even an experienced and theoretically trained engineer will read the whole book, finding an observation or information of great interest on every page.

The reviewer, however, thinks that the book has one shortcoming: given such a wide range of interests, its style is sometimes too condensed. Every page of the book contains so many data that their elaboration or documentation with pictures might prove useful, especially for the benefit of young engineers. Since the book will undoubtedly come out in a second edition, it would deserve to be enlarged by a few dozen pages.

V. Mencl, Czechoslovakia

1820. Nishida, Y., The determination of point resistance of piles (in German), *Bauingenieur* **32**, 8, 291–294, Aug. 1957.

Author derives approximate expression of ultimate point resistance of piles on basis of theory of elasticity. Method is evaluated for cohesionless soils and compared with results based on theory of plasticity. Writer considers latter theory is preferable approach to estimates of ultimate loads.

G. G. Meyerhof, Canada

1821. Jenne, G., Contribution to the calculation of free bulkhead walls (in German) *Bauingenieur* **32**, 8, 294–297, Aug. 1957.

Blum's method based on coefficient of subgrade reaction for designing free bulkhead walls is evaluated and represented by author in graphical form to determine minimum depth of penetration and maximum bending moment of wall. While active earth pressure can have any distribution, proposed method is limited to linear variation with depth of passive earth pressure. Latter assumption is not compatible with deformation condition at lower part of wall.

G. G. Meyerhof, Canada

1822. Grushko, G. S., Distribution of stresses in horizontal mine workings of semi-circular shape (in Russian), *Naucb. tr. Kharkovsk. gorn. in-ta* no. 2, 59–67, 1955; *Ref. Zb. Mekb.* 1956, Rev. 5429.

By means of the G. V. Kolosov and N. I. Muskhelishvili method, an approximate solution of the problem of stress distribution in a semiplane with an opening in it is given in two limiting cases: (a) opening not reinforced (absolutely flexible ring); (b) opening reinforced by an absolutely rigid ring.

For solution of the problem, a function representing the exterior of a semicircle by the exterior of a single circle is constructed. The author, limiting himself to the finite number of a series, makes the reflecting function of the following form

$$Z = \frac{\sqrt{3}\,i}{9}\left(2 - \frac{4}{\zeta} + \frac{5}{4}\zeta + \frac{5}{8}\zeta^2 + \frac{13}{64}\zeta^3\right)$$

Tables of the value of the stresses over the contour of the opening and the graphs of the stress variation are given.

A. Ya. Gorgidze

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1823. Kuryllo, A. S., Investigation of columns having an oblique reinforcemtnt (in Russian), *Naucb. zap. Lvovsk. politekbn. in-ta* no. 19, 3–63, 1954; *Ref. Zb. Mekb.* 1956, Rev. 5518.

An investigation of the carrying capacity of short centrally compressed ferro-concrete columns with various pitch and section of the spiral steel reinforcement. Ferro-concrete supports of a height of 60 mm were tested; some were of octagonal section with a round concrete core of diameter 20 cm and others of square section 20 × 20 cm.

The strength of the concrete when compressed in different specimens fluctuated within the limits of 75 and 319 kg/cm^2. The supports of octagonal section were reinforced by eight longitudinal rods, and the supports of square section were reinforced by four longitudinal rods with a diameter between 12 and 16 mm. The percentage of the spiral reinforcement $\gamma = 100\, F_c/F_{core}$ in the various supports varied between 1.45 and 7.08% (F_c is the volume of the spiral reinforcement per unit length of the support, F_{core} is the area of the section enclosed by the spiral ring). The diameter of the spiral reinforcement in various specimens varied between 5 and 10 mm.

The values of the destructive loads and of the force-deformation diagram for 108 tests of the ferro-concrete supports are given.

On the basis of the test data it is suggested that the permissible load for compressed columns with a spiral reinforcement

should be calculated by the following formula

$$P = \frac{1}{K}(\alpha\beta R_{pr} F_{core} + \sigma_T F_a)$$

where K is the reserve coefficient; R_k and R_{pr} are the cubic and prism strength of concrete during compression; σ_T and F_a are the flow limit and the cross-sectional area of the compressed longitudinal reinforcement; $\alpha = 1$ for the element of the square section and $\beta = 220/R_k$ for the circular section element;

For the coefficient $\alpha = \alpha(\gamma)$ the following test data are given:

	$\gamma = 0.8\%$	2%	6.5%	7%
For a round column	$\alpha = 1.3$	2	—	3.11
For a square column	$\alpha = 1.3$	1.7	2.15	—

V. V. Pinadzhyan
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1824. Cornell, W. G., Losses in flow normal to plane screens, ASME Fall Meet., Hartford, Conn., Sept. 1957. Pap. 57-F-19, 7 pp.

Experimental data are correlated for total-pressure losses in subsonic-compressible, real-fluid flow normal to plane round-wire screens of square mesh, including new data at very high screen Reynolds number. A theory is developed for subsonic-compressible flow normal to plane screens of sharp-edged elements of any geometry, yielding predicted total-pressure losses which compare reasonably well with experimental data. The effect of Reynolds number on loss is found to be small, except at very low Reynolds number.

From author's summary by G. J. Nothwang, USA

1825. Leczfalvy, S., Evaluation of the effect of artificial water level depression upon natural water resources (in Hungarian), *Mélyépitestudomanyi Szemle* **7**, 7/8, 258–260, July/Aug. 1957.

An equation of a depression curve from a constant origin is derived and intersection with a natural water table of known shape is computed. S. Kolupaila, USA

1826. Barenblatt, G. L., On self-similar solutions of the Cauchy problem for the nonlinear parabolic equation of the nonsteady filtration of a gas in a porous medium (in Russian), *Prikl. Mat. Mekh.* **20**, 6, 761–763, 1956 (translated from Russian by M. D. Friedman, 572 California St., Newtonville 60, Mass., 6 pp.).

Paper concerns solution of equation $p_t = (a^2/r) \cdot p_r(r \cdot p_r^3)$, t being time, r the distance of flow axis of symmetry, and a a constant depending on properties of gas and medium. Boundary conditions are $p(r,0) = \sigma r^\alpha$, $\sigma = \text{const} > 0$, $\alpha = \text{const} > 0$ and $p_r = 0$ at $r = 0$. Solution is shown to be possible for $0 < \alpha < 2$ for all t in interval $0 \le t \le \infty$, but for $\alpha = 20$, solution exists only in interval $0 \le t < T$, where $T = 1/16a^2\sigma$. For $\alpha > 2$, solution is not unique. All three cases are fully dealt with. For the case $\alpha = 2$ and t-values $(0,T)$, $p(r,t) = \sigma r^2/(1 - 16a^2\sigma t)$. This solution is infinite for all r at $t = T$. An excellent treatment for conditions $\alpha > 2$ is given. The Friedman translation is excellent.

J. M. DallaValle, USA

1827. Vakhitov, G. G., The inflow of petroleum to boreholes in strata of irregular permeability (in Russian), Thesis, All-Soviet Scientific Research Institute for Petroleum Gases, Moscow, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7640.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1828. Charnyi, I. A., Inflow to wells in strata of unequal permeability, *Inzbener. Sbornik, Akad. Nauk SSSR* **18**, 31–40, 1954.

Author treats the flow to wells which are located in two strip strata parallel to their vertical contact where the parameter $c = kh/\mu$ changes suddenly (k = permeability, h stratum thickness, μ viscosity of liquid). It is assumed that Darcy's law is valid and that the boundary pressures are known. The flow to the wells of both rows is governed by Laplace equations whose constants are determined by continuity condition at the contact of the strata and by boundary requirements assuming either constancy of boundary pressures or impermeability of the boundary.

In an analogous way is treated the flow to wells located in a circular stratum of constant parameter c_0 and either isolated or grouped inside circular fields of various parameters c_j. In the first step, such fields are substituted by fictive wells which themselves are then treated as circular strata of second degree. The pressures on the surfaces of fictive wells are dealt with as supplementary intermediate unknowns. This solution can be applied also for strata with oval boundary and irregular enclosures, using the method of conformal transformation.

Finally, two examples are given. L. Suklje, Yugoslavia

1829. Pokrovskii, B. I., Calculation of seepage through discharge face, *Inzbener. Sbornik, Akad. Nauk SSSR* **18**, 41–48, 1954.

Based on the solutions of S. V. Fal'kovich for the discharge at the foot of an arbitrary inclined slope and of T. J. Polubarinova-Kochina for the seepage through a vertical face, author develops the approximate integral flow curve along a vertical discharge face, assuming that the flow is determined by the distance from the breakout point and the inclination of flow in the corresponding point. This curve enables then to construct the flow-line inclinations at the downstream slope as a function of the slope inclination and of the position along the slope. Using the obtained curve and assuming that the flow lines are straight in the discharge area, author gives a method for the flow net construction in the neighborhood of a vertical discharge face and the application of the same method in case of an arbitrary inclined slope.

All deductions are based on the assumptions that the water flows from infinity and that there is no water at the toe of the slope. The method can, however, be enlarged for final seepage ways. L. Suklje, Yugoslavia

Micromeritics

(See also Revs. 1532, 1647, 1824, 1827, 1828, 1829)

1830. Sugawara, S., and Kikkawa, S., Researches on the acceleration of a particle in a horizontal pipe and its flying distance, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 349–352.

Lateral distribution of coal particles on a furnace grate is considered. Particles are transported into the firebox through a horizontal two-dimensional air duct placed above the grate level. The uniform air velocity within the duct is assumed to continue horizontally into the firebox. The air velocity in the remainder of the firebox is uniform and is directed vertically upward. Lateral position of the particles on the grate is deduced from the equations of motion in terms of the velocity and vertical position of the particle at the duct outlet.

The average velocity and elevation of the particles is deduced by considering the particles to be transported by saltation within the duct.

Reviewer believes that the derivations are based upon assumptions that are too naive to be representative of the phenomenon. The analysis of saltation transport could have been improved by reference to well-known papers on this subject, such as Kalinske, *Trans. Amer. geophys. Un.*, pt. II, 639–643, 1942.

M. R. Carstens, USA

1831. Iwagaki, Y., On the river-bed variation and its stability, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 361–366.

Author presents a new method for analyzing river-bed variation in a river transporting sediment as bed-load. A stepwise calculation is employed, based on the characteristic equation of the fundamental differential equation for the flow, neglecting hydraulic gradient and variations in flow rate. Cases analyzed are: (1) a mound of subcritical slope on the river-bed, (2) a supercritical mound, and (3) critical depth at a reservoir and dam.

The analysis holds mainly for river-bed variations that are long compared with the depth of the water. The river bed is shown to be stable.

C. F. Bonilla, USA

1832. Akopyan, L. A., and Kasatkin, A. G., Hydrodynamics of the layer of grain material (in Russian), *Khim. prom-st.* no. 2, 30–33, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5318.

On the basis of the analysis of much experimental data published previously an investigation is made of the resistance of a layer of grain material and of the speed of pseudo-liquefaction and removal of the layer. The coefficient of resistance of the layer is expressed as a function of resistance of a certain standard layer. The resistance of a layer consisting of ball bearings of a diameter of 2, 4 and 6 mm was taken as the standard.

The resistance coefficient of the standard layer λ is sought in relation to the Reynolds number R, referred to the diameter of the balls forming a filtration layer. The graphical relation of λ to R is given from the author's tests in the range of $0.1 < R < 1000$.

$$\lambda = \frac{220}{R} \qquad (R < 35)$$

$$\lambda = \frac{11.6}{R^{\frac{1}{4}}} \qquad (35 < R < 7000)$$

The resistance of the layer made up of grains of incorrect shape, it is suggested, should be determined from the standard resistance with the aid of special conversion formulas.

The speed of the pseudo-liquefaction is determined from the equation of the weight of the grain layer and the pressure on its cross section.

The rate of removal of the particles is determined from the equation for the weight of the specific particle and of the lifting force acting on it. Formulas and graphs are given for calculation of the rates of pseudo-liquefaction and removal.

E. M. Minskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Geophysics, Meteorology, Oceanography

(See also Revs. 1521, 1589)

1833. Massaelian, Sh. A., The three-dimensional problem of the flow around a terrestrial protuberance with account of the sphericity of the earth (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **103,** 5, 815–818, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7598.

It is assumed that the emotion of the atmosphere is represented by a purely zonal circulation with superposed perturbation due to the flow around irregularities on the earth's surface. The adiabatic phenomena are analyzed, using the method of long waves. Author has succeeded in reducing the problem to a linear equation in partial derivatives with coefficients depending on the geographical latitude. Analysis of this equation enables two typical phenomena to be isolated, the characteristics of which are determined by the dimensions of the protuberances on the earth's surface. In the first case, relating to the flow around large mountain masses, the amplitude of the pressure perturbations decreases with altitude according to an exponential law. In the second case (hills), the perturbations vary with altitude according to a sinusoidal law.

S. A. Mashkovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1834. Bullen, N. I., The variation of gust frequency with gust velocity and altitude, *Aero. Res. Counc. Lond. curr. Pap.* 324, 6 pp. + 7 figs., 1957.

1835. Allan, R. M., Results of a flight investigation on clear air turbulence at low altitude using a Meteor Mk: 7 aircraft, *Aero. Res. Counc. Lond. curr. Pap.* 329, 10 pp. + 6 figs., 1957.

1836. Heath-Smith, J. R., Atmospheric turbulence encountered by Hermes aircraft, *Aero. Res. Counc. Lond. curr. Pap.* 334, 16 pp. + 4 figs., 1957.

Marine Engineering Problems

1837. Newman, J. N., On the damping of pitch and heave, *J. Ship Res.* **1,** 2, 48–53, July 1957.

Author sets out to develop approximate but tractable formulas for the heave and pitch damping coefficients for ships after noting that previous investigators have (a) not completed their analyses [Brard, R., *Bull. Assn. tech. marit. aéro* 1948], (b) have considered only uncoupled motions at zero forward speed [Havelock, T., *Trans. INA* 1956] and (c) have given a comprehensive treatment leading to an answer which is too complicated for practical use [Haskind, M.D., *SNAME Bull.* no. 1–12, 1953].

Havelock's approach is utilized and approximate formulas are found which are stated to be applicable to "low speeds," but the speed, or more properly the Froude-number range of validity, is not given.

Restriction to small speeds and frequencies or to small values of the parameter $\tau = \omega U/g$ (ω = frequency of encounter, U ship speed, g gravity constant) is entailed by the use of an asymptotic expression for the potential of a pulsating source and the "fact" that the ship cannot be represented by pulsating sources alone except at low frequencies. The asymptotic form is obtained by retaining only linear terms in τ. In order to give an idea as to the type of ship for which this may be expected to be allowable, author presents a table of typical values of τ which range from 0.16 for a Victory ship to 0.86 for a destroyer. The linearization is therefore restricted to slow ships. Results of calculations for heave and pitch damping coefficients are presented for the case of the Series 60, 0.60 block coefficient hull at zero speed of advance. Comparison with results of calculations using two-dimensional concepts shows correspondence for heave but considerable differences are found for pitch and cross coupling coefficients.

The comparison is not decisive, since the author's evaluation is based on a number of assumptions and the numerical evaluation is approximate. Reviewer finds this paper stimulating but overly brief in regard to the development of the basic potential function and in the discussion of the results.

J. P. Breslin, USA

1838. Morgan, W. B., Effect of propeller pitch changes on torque unbalance of counterrotating propellers, *David W. Taylor Mod. Basin Rep.* 1124, 5 pp., Mar. 1957.

Theoretical study on the effect of small changes in pitch (due to manufacturing inaccuracies) on torque balance. Results show that the effect of pitch change is dependent on whether the forward or aft propeller pitch is changed and on propeller loading. A change in pitch on the aft propeller has a greater effect on the torque unbalance. Relative to propeller loading, lighter loaded propellers are more sensitive to pitch change than heavier loaded

propellers. On the average a 1% change in pitch causes an approximate unbalance of 8% in torque.

H. W. Lerbs, Germany

1839. Proskuriakov, A. P., Theory of propelling screw for the zero angle of attack (in Russian), *Prikl. Mat. Mekh.* **20**, 4, 519-531, July-Aug. 1956.

G. I. Maikapar [*Trudy Central. Aero-Gidrodin. Inst.* no. 613, 1947] extended the Zhukovskiĭ vortex theory to the propelling screw for an arbitrary angle of attack. Free vortices leaving the blades at radius r are replaced by a vortex sheet over the surface of an oblique cylinder, the base of which is of radius r. This vortex sheet is imagined to be in the form of two superimposed sheets: a sheet of rectilinear vortices along the generators of the cylinder, and a sheet of circular vortices parallel to the base of the cylinder.

According to author, A. I. Sluckiĭ (reference not quoted), using Maikapar's results, considered a particular case of the propelling screw theory for the zero angle of attack. In this case the cylindrical vortex sheet reduces to a planar one which consists of a sheet of longitudinal rectilinear vortices and a sheet of circular vortices.

Wildgrube (1950) discussed the same particular case as Sluckiĭ, without making any reference to the formulas obtained by Maikapar. His results, however, according to author, have proved to be erroneous.

In the present paper the flow around a propelling screw for the zero angle of attack is considered anew, and formulas for the induced velocity are derived for the whole space.

E. Leimanis, Canada

1840. Hogben, N., Ship hull pressure measurements, *Trans. Instn. nav. Arch. Lond.* **99**, 3 (part II), 446-472, July 1957.

1841. Lindgren, H., and Bjarne, E., Tests with geometrically similar models of the Victory ship, *Medd. SkeppsProvAnst. Göteborg*, no. 40, 39 pp., 1957.

Lubrication; Bearings; Wear

1842. Orbeck, F., Theory of oil whip for vertical rotors supported by plain journal bearings, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-171, 18 pp.

At certain operating conditions the journal will describe a rotating movement in the bearing with a number of revolutions of about half the number of the revolutions of the rotor. Authur has tried to define this movement and to determine the speed revolution range where this phenomenon appears at defined operating conditions.

Assuming that the center of the shaft pivot moves in a circular path with a constant velocity, author forms the force equilibrium equation between the centrifugal force and the forces on the journal from the oil film, using well-known theories. The method can only be strictly applied to vertical rotors (gravity has no effect).

By examples author illustrates how $\omega_{whirl}/\omega_{shaft}$ for a certain bearing varies from 0.464 to 0.499 when the eccentricity ratio varies from ~0.05 to 0.8. This corresponds to experiments carried out by others.

Author compares results obtained experimentally by Newkirk to his own calculations, and attains good agreement at high number of revolutions. The lack of agreement at low speed is related by author to the effect of the rotor weight. Paper gives further viewpoints on a topical problem. Reviewer suggests a summing up of the theories delivered up to now [compare, for instance, with "Oil whirl in bearings" by A. Cameron, *Engineering* Febr. 25, 1955] and further tests in such a way that the theories can be technically applicable.

I. Jung, Sweden

1843. Osterle, J. F., Chou, Y. T., and Saibel, E. A., The effect of lubricant inertia in journal-bearing lubrication, *J. appl. Mech.* **24**, 4, 494-496, Dec. 1957.

The steady-state equation for pressure variation along the film is developed so as to retain the inertia terms. An approximate solution of this equation is obtained by averaging the inertia over the film thickness. The resulting expression for inertia effect is applied to a specific case at the critical Reynolds number, revealing a pressure correction of (only ?) 4%.

E. J. McBride, USA

1844. Guilinger, W. H., and Saibel, E., Numerical methods of solution of the adiabatic slider bearing without side leakage, Proc. Fifth Midwestern Conf. Fluid Mech., Apr. 1957, 285-297.

Two methods are described for solving Reynolds' equation in two dimensions by digital computer. Viscosity is related to temperature and pressure by arbitrary exponential functions and the bearing studied is a simple slider bearing wherein film thickness is related to position by a further exponential function. Boundary conditions are defined by pressure equal to zero at inlet and outlet. In the first method, a constant K, derived from the continuity equation, is substituted into the flow equation and then into the energy equation. An approximate value of K is derived from the isothermal case and a method is described for adjusting this value for the adiabatic case so as to satisfy the outlet boundary condition.

In the second method temperature and pressure distributions are derived from Reynolds' differential equation by an iterative process. The first method is recommended for accuracy whereas the second, being simpler, is presented because it offers promise of generalization to include the side leakage case. The authors recommend caution however because they believe that it should be investigated more extensively before this step is taken.

Reviewer considers that methods outlined offer promise of solving many outstanding problems in hydrodynamic lubrication. Difficulties yet to be overcome are allowance for the effect of conductivity and, in the case of journal bearings, the determination of realistic boundary conditions.

F. T. Barwell, Scotland

1845. Grinnell, S. K., and Richardson, H. H., Design study of a hydrostatic gas bearing with inherent orifice compensation, *Trans. ASME* **79**, 1, 11-21, Jan. 1957.

1846. Taber, R. D., and Robbins, F. A., Development of the teflon-based piston rings for nonlubricated applications, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-67, 8 pp.

1847. Hasselgruber, H., Calculation of the lubricating oil supply of internal combustion engines (in German), *Motortech. Z.* **18**, 8, 235-241, Aug. 1957.

For the design of an internal combustion engine it is of interest to know the distribution of the lube oil to the individual bearings and to estimate the oil pressures to be expected. It is shown what information concerning these problems may be obtained by means of relatively simple relations derived from the hydrodynamic bearing theory. The application of the equations presented is explained by a numerical example.

From author's summary by A. G. Cattaneo, USA

1848. Extreme pressure lubricants, *Lubrication* **43**, 6, 65-76, June 1957.

Letters to the Editor

1849. Regarding AMR 9, Review 1513 (May 1956): Hoerner, S. V., Solutions of hydrodynamic equations with linear change of velocity (in German), *Z. Naturforsch.* **10a,** 9/10, 687-692, Sept./Oct. 1955.

Reviewer of the above paper at the time he was preparing reviews of related papers by the same author which appear in this issue (Reviews No. 1692 thru 1699) found that: The solutions under discussion (homology solution) hold only for the region behind the shock where the effect of viscosity and heat conduction is negligible. At the same time, the solution said to "represent" the strong shock satisfies the condition imposed by the strong shock as boundary condition.

H. P. Eichenberger

Books Received for Review

ALGER, P. L., Mathematics for science and engineering, New York, McGraw-Hill, 1957, xi + 360 pp. $5.50.

ARGHYROPOULOS, P., Calcul de l'ecoulement en conduites sous pression ou a surface libre, Paris, Dunod, 1958, xiii + 326 pp.

BUCK, R. C., Advanced calculus, New York, McGraw-Hill, 1956, viii + 423 pp. $8.50.

Bulletin de l'association technique maritime et aeronautique, No. 56, Session de 1957, Paris, Association Technique Maritime et Aeronautique, 1957, 862 pp.

CONWAY, H. G., edited by, Aircraft hydraulics. Vol. I: Hydraulic systems, New York, Macmillan, 1957, ix + 146 pp. $7.00.

CONWAY, H. G., edited by, Aircraft hydraulics. Vol. II: Component design, New York, Macmillan, 1957, ix + 198 pp. $9.00.

DIENES, P., The Taylor series; an introduction to the theory of functions of a complex variable, New York, Dover Publications, 1957, x + 552 pp. $2.75. (Paperbound).

GAYLORD, E. H., Jr., and Gaylord, C. N., Design of steel structures, New York, McGraw-Hill, 1957, xiii + 540 pp. $8.00.

GRASSIE, J. C., Analysis of indeterminate structures, New York, Longmans, Green and Co., 1957, viii + 418 pp. $9.75.

HOBSON, E. W., A treatise on plane and advanced trigonometry, seventh edition, New York, Dover Publications, 1957, xv + 381 pp. $1.65. (Paperbound).

JEFFERSON, S., Radioisotopes; a new tool for industry, New York, Philosophical Library, 1958, 110 pp. $4.75.

KUNZ, K. S., Numerical analysis, New York, McGraw-Hill, 1957, xv + 381 pp. $8.00

LETTAU, H. H., and DAVIDSON, B., Exploring the atmosphere's first mile. Vol. 1: Instrumentation and data evaluation, New York, Pergamon Press, 1957, xiv + 376 pp. $10.00.

LUCAS, G., and POLLOCK, J. F., Gas turbine materials, New York, Macmillan, 1958, xi + 163 pp. $5.75.

MCCONNELL, A. J., Applications of tensor analysis, 1957, xii + 318 pp. $1.85.

MACDUFF, J. N., Vibration control, New York, McGraw-Hill, 1958, vii + 465 pp. $9.00.

NERVI, P. L., Structures, New York, F. W. Dodge Corp., 1956, x + 118 pp. $6.95.

PETROVSKII, I. G., Integral equations, translated from the second revised Russian edition, Rochester, New York, Gralock Press, 1957, vi + 97 pp.

PHISTER, M., Jr., Logical design of digital computers, New York, John Wiley & Sons, 1958, xvi + 408 pp. $10.50.

ROGERS, G. F. C., and MAYHEW, Y. R., Engineering thermodynamics work and heat transfer, New York, Longmans, Green and Co., 1957, x + 618 pp. $9.75.

SEDOV, L. I., Metody podobiya i razmernosti v mekhanike, Moscow, Gosudarstvennoe Izdatel'stvo tekhniko-teoreticheskoi literatury, 1957, 375 pp.

Symposium sur l'observation des ouvrages. Symposium on the observation of structures. Vol. I: General report and discussion, Lisboa, Laboratorio Nacional de Engenharia Civil, 1955; vii + 228 pp.

Symposium sur l'observation des ouvrages. Symposium on the observation of structures. Vol. II., Papers, Lisboa, Laboratorio Nacional de Engenharia Civil, 1955, vii + 1027 pp.

SZABO, I., Einfuhrung in die Technische Mechanik, Berlin, Springer-Verlag, 1958, xii + 419 pp. DM 22.50.

VOGELPOHL, G., Betriebssichere Gleitlager, Berlin, Springer-Verlag, 1958, xii + 315 pp. DM 46.60.

ZELIKOFF, M., edited by, The threshold of space, New York, Pergamon Press, 1957, xi + 342 pp. $15.00.

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